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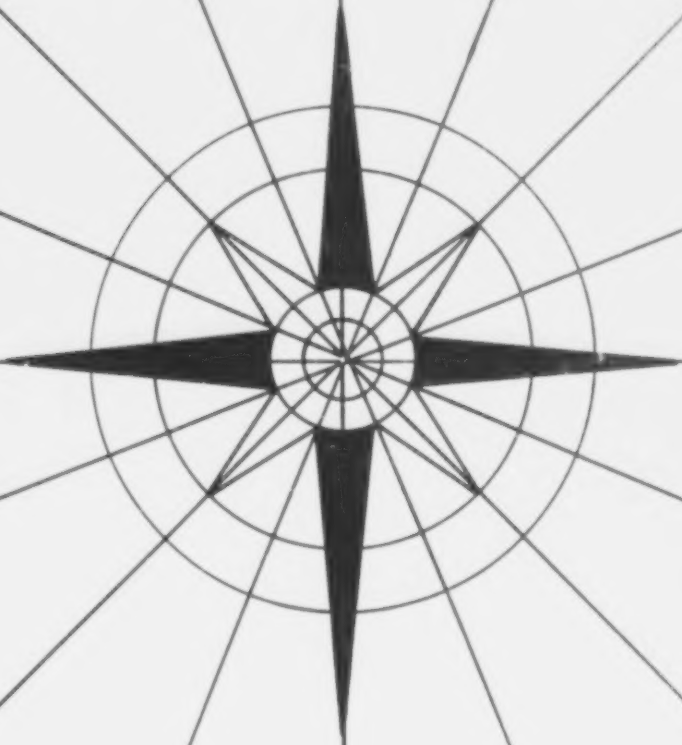
8SL17: Natural Site-Formation Processes of a Multiple-Component Underwater Site in Florida

SUBMERGED CULTURAL RESOURCES SPECIAL REPORT



LARRY E. MURPHY
SUBMERGED CULTURAL RESOURCES UNIT
NATIONAL PARK SERVICE

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8SL17: NATURAL SITE-FORMATION PROCESSES OF A MULTIPLE-COMPONENT UNDERWATER SITE IN FLORIDA

8SL17: NATURAL SITE-FORMATION PROCESSES OF A MULTIPLE-COMPONENT UNDERWATER SITE IN FLORIDA

by

Larry E. Murphy

With a Contribution by Linda Scott Cummings

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REPORT AND PUBLICATION SERIES

The Submerged Cultural Resources Unit was established in 1980 to conduct research on submerged cultural resources throughout the National Park System with an emphasis on historic shipwrecks. One of the unit's primary responsibilities is to disseminate the results of research to National Park Service managers, as well as the professional community, in a form that meets resource management needs and adds to our understanding of the resource base. A report series has been initiated in order to fulfill this responsibility. The following are the categories of reports that comprise this series.

Submerged Cultural Resources Assessment

First line document that consists of a brief literature search, an overview of the maritime history and the known or potential underwater sites in the park, and preliminary recommendations for long-term management. It is designed to have application to GMP/DCP's and to become a source document for a park's Submerged Cultural Resources Management Plan.

Submerged Cultural Resources Survey

Comprehensive examination of blocks of park lands for the purpose of locating and identifying as much of the submerged cultural resources base as possible. A comprehensive literature search would most likely be a part of the Phase I report but, in some cases, may be postponed until Phase II.

Phase I -- Reconnaissance of target areas with remote sensing and visual survey techniques to establish location of any archeological sites or anomalous features that may suggest the presence of archeological sites.

Phase II -- Evaluation of archeological sites or anomalous features derived from remote sensing instruments to confirm their nature and, if possible, their significance. This may involve exploratory removal of overburden.

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A document that discusses, in detail, all known underwater archeological sites in a given park. This may involve test excavations. The intended audience is managerial and professional, not the general public.

Submerged Cultural Resources Site Report

Exhaustive documentation of one archeological site which may involve a partial or complete site excavation. The intended audience is primarily professional and incidentally managerial. Although the document may be useful to a park's interpretive specialists because of its information content, it would probably not be suitable for general distribution to park visitors.

Submerged Cultural Resources Special Report Series

These may be in published or photocopy format. Included are special commentaries, papers on methodological or technical issues pertinent to underwater archeology, or any miscellaneous report that does not appropriately fit into one of the other categories.

Daniel J. Lenihan

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ABSTRACT

In the 1960s, commercial treasure salvors of 1715 Spanish Plate Fleet shipwrecks off the east coast of Florida encountered prehistoric artifacts and extinct animal fossils. At first the salvors believed the material to be wreck-related, but later examination by archeologists indicated it was not associated with the wreck. In 1976 Florida archeologists considered the possibility that the shipwreck might lie over an inundated terrestrial site. In 1978 fieldwork was conducted to determine the nature of the terrestrial site and the site-formation processes that allowed its preservation. Although the fieldwork was done within the confines of commercial treasure salvage, sufficient controls were exercised to make some observations regarding the site-formation processes of both sites. The results of the research are discussed here, focusing on the terrestrial site and its relevance to understanding processes of inundation and preservation, and extrapolating to locate other continental shelf sites. The report conclusions present two newly derived principles of site-formation processes relevant to historical and marine-inundated terrestrial sites.

FOREWORD

One issue in underwater archeology sorely in need of attention is distinguishing natural changes from cultural depositions. Understanding site-formation processes is as key to unraveling archeological riddles as the understanding of material remains themselves. I am particularly pleased, therefore, that this office is able to bring this report by Larry Murphy to a wider audience.

The field work for this paper was performed while Larry was working for the Florida Division of Historical Resources, Bureau of Archeological Research and originally served as a thesis for part of his doctoral graduate work at Brown University. Its application, however, is broad and should be of interest to anyone in the field of archeology regardless of institutional persuasion.

This is the first of the "special reports" in the Submerged Cultural Resources Unit's publication series. These are papers not necessarily tied to any particular park or jurisdictional entity, but dealing with generic problems relevant to the entire endeavor of underwater archeology and, by definition, to the archeological discipline as a whole. The fascinating example of a historic shipwreck intermingled with a prehistoric component in a multidimensional site is a dramatic vehicle for addressing such questions on submerged sites.

Certainly all underwater archeologists have to deal with the issue of site formation in an implicit way or in brief discussions tied to their site interpretations. The value of this report is that it explicitly addresses the problem: It opens the can of worms and spills them out for the enjoyment of all. I commend the reader to what I feel is a refreshing treatment of a subject they will recognize as a familiar companion who has been previously held at arm's length.

Daniel Lenihan
Chief, Submerged Cultural Resources Unit
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Dan Clayton, Florida Research and Conservation Laboratory of Bureau of Archeological Research, did the initial faunal identification. Greg MacDonald, Cincinnati Museum of Natural History Curator of Vertebrate Paleontology, also reviewed the faunal materials. Linda Scott Cummings of PaleoResearch Laboratories, Denver, Colorado, conducted the pollen analysis. Don Meyer of Rock River Laboratory, Watertown, Wisconsin, performed the geochemical analysis. John Husler, Geology Department, University of New Mexico, generated the sedimentological and point-count data. Much of the laboratory analysis was funded by the Submerged Cultural Resources Unit of the National Park Service for the purposes of refining submerged-site recognition methodology for application to NPS areas. Donna Souza, Social Science Data Center, Brown University, assisted with the discriminant analysis.

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Richard MacAllaster of Peninsular Exploration and Salvage Corporation and his crew cooperated in field data collection.

CHAPTER I: INTRODUCTION

This publication seeks to correct a major weakness limiting the study of underwater archeological sites: a set of unquestioned assumptions regarding site-formation processes and data-set preservation. The subject of research, the Douglass Beach Site (8SL17), is a Florida east coast underwater site consisting of two components: an 18th-century Spanish shipwreck located above an Archaic Period inundated terrestrial site. This dual-component site provides the opportunity to observe site-formation processes pertinent to both components. Douglass Beach Site research was aimed at generating principles of submerged site formation and alteration. The primary research was conducted over seven weeks in summer 1978.

In recent years archeological researchers have become interested in formation processes and their implications for inference. Michael B. Schiffer's (1976; 1987) theory accounting for variability in the material record has been especially influential. Schiffer recognized two kinds of formation processes affecting archeological remains: cultural, where the transformational agency is human behavior; and non-cultural, in which the agency is the natural environment. Both processes exhibit regularities that can be expressed as (usually statistical) laws (Schiffer 1987:7, 11). In this report, research deals only with natural processes, specifically with the formation of inundated sites and historical shipwrecks, and marine transgression impact on prehistoric sites.

Research objectives on the prehistoric component are to determine which archeological data sets survived the biological, chemical and mechanical effects of the marine transgressive sequence in a high-energy, shallow-water environment and long-term immersion, and then to account for their preservation. At the time of the original research (1978), little was known of the effects of inundation on archeological data. In 1981 Lenihan et al. (1981) completed the National Reservoir Inundation Study, which examined freshwater impact on archeological sites. To date, no comparable study exists for marine inundation.

Existence of offshore prehistoric sites has long been postulated, but attempts to locate any have been mostly unsuccessful. Recently a model and methodology to locate terrestrial sites on the Outer Continental Shelf was developed (Gagliano et al. 1976; 1982) and tested (Pearson et al. 1986). The research reported here applies Gagliano's methodology and compares analytical results to his model, which was based on known coastal sites.

Douglass Beach Site field research allowed observations of the natural-formation processes of shipwrecks. The implications of those observations force a reassessment of current thinking on shipwreck site processes in high-energy areas.

Research in this report is not the first on underwater site-formation processes, but augments a comparative examination of natural processes active on shipwreck sites in England by Muckelroy (1978:160-196), one of the first to recognize that certain features were common to England's shipwreck sites.

A brief historical overview of Florida shipwreck salvage is important to provide context, as well as to explain the operative thinking that influenced the work of earlier archeologists.

In the 1960s and 1970s, the early days of shipwreck salvage, certain "common-sense" ideas, unquestioned and untested, prevailed regarding the nature of underwater archeological sites. The pivotal assumption was that high-energy coastline shipwrecks break up, randomly scatter, and continually degenerate. In Florida, these ideas deadened research questions and justified minimal archeological recording standards on governmentally supervised commercial excavation of internationally significant historic sites.

Relying on this "common-sense" thinking, modern salvors and archeologists assumed that shipwrecks were jumbled and continually dispersed by the high-energy wave action of the shallow Florida Atlantic coast. This "disaster-and-degeneration" view prevailed particularly among salvors, who assumed that if degeneration continued, eventually nothing would be left. Hence, commercial salvage was justified.

In 1964 commercial historic shipwreck salvage in Florida began with the 1715 Spanish Plate Fleet, located near Vero Beach and Fort Pierce on the Atlantic coastline. Beginning in the 16th century, ships grouped in what are known as plate fleets annually transported New World products, especially gold, silver and dyestuffs, to Spain.

In July 1715, all 11 ships of the heavily laden plate fleet--the first fleet to leave the New World in over a decade--sank in a hurricane that drove the ships onto shallow offshore reefs, where they broke up. Material washed ashore, and the Spanish salvaged what they could in years immediately following the wrecks.

In the early 1960s, the sites were rediscovered after beachcombers found Spanish coins, and surveys in shallow water located vessel remains. Commercial salvage operations recovered numerous artifact concentrations, prodigious amounts of gold and silver coins, bullion and artifacts. Florida claimed ownership, passed an antiquities law and began to supervise the operations after salvors were put under state contract. The antiquities legislation provided for artifact division (usually 25% to the state, 75% to the salvors). The state placed field agents on board contractors' vessels to monitor salvage operations. Later the state attempted to collect archeological data.

Salvage efforts were haphazard and unsystematic. Salvors opened large holes in the seabed and frequently repositioned the salvage vessel to follow wreckage "trails." The impression of jumbled, scattered sites was reinforced by the excavation methodology.

Occasionally, salvors working a 1715 shipwreck site (8SL17) at Douglass Beach recovered prehistoric artifacts, bones and fossils. Although prehistoric artifacts infrequently surfaced at the site, salvors assumed they were not associated with the shipwreck and consequently were seldom recorded, even after archeologists began to supervise the salvage program for the state. The implications of these prehistoric materials, which are the subject of this report, were not then realized because of assumptions held by those involved.

The disaster-and-degeneration view influenced both shipwreck research and the approach to inundated terrestrial sites. With wrecks, the view justified salvage (the salvors were performing an important service by recovering the artifacts before their inevitable loss) and minimal archeological control (the material, so obviously jumbled, was incomprehensible). Little could be gained from wrecks that could not be more easily obtained from archives. For scientists interested in examining submerged terrestrial sites, the implications were clear: If one assumed that wave action from the initial inundation and subsequent storms destroyed submerged sites on high-energy coastlines, then systematic research should be directed to low-energy coastlines. Few archeological data would survive in a high-energy environment.

In recent years archeologists scrutinizing site-formation processes have contradicted the disaster-and-degeneration view. They have demonstrated that while archeological remains are affected by both cultural and natural forces during and after deposition, they are not jumbled, nor do they continually degenerate. The consequences of deposition are not absolute and random but discernible and predictable and can be expressed by general principles (Schiffer 1976; 1987). The specific examination of formation processes and the formulation of general principles enhances archeological inference and interpretation. This research has, in effect, changed how we look at the archeological record and what we expect to learn from it.

One of the most important aspects of the Douglass Beach Site is the evidence of two disparate occupations--an Archaic site and a shipwreck--that enables an examination of an underwater site with two very different formation processes. The site research forces a revised examination of assumptions and methodological approaches appropriate to shipwrecks and inundated terrestrial sites in shallow water.

The Archaic Period inundated terrestrial site, which has a well-preserved stratigraphy, prompts a revision of the current continental shelf site-location model to include areas where sites are now unexpected. The stratigraphy provides an opportunity to test analytical tools for site recognition.

The co-occurrence of an Archaic site and a shipwreck raises another issue, that of structural differences between the two. The shipwreck is the result of an event, the terrestrial site the result of a long process of accumulation and deposition. New theories of site-formation processes must be developed to account for the variables of both sites represented at 8SL17. While this study focuses on preservation of the terrestrial site, complete analysis of both sites will eventually have to explain the variation between the sites as a function of cultural and natural formation processes.

In sum, the theoretical orientation here is Schiffer's, the methodological approach follows Gagliano et al. (1982) and Pearson et al. (1986). The following three chapters present the field methodology, geological processes and analysis of Douglass Beach materials. Prehistoric site analysis, using standard sedimentary and geochemical procedures, is compared to Gagliano's continental shelf site-recognition model, and suggestions for improvement are offered. Wave and barrier-island processes are discussed along with evidence from both site components to account for the high level of prehistoric site preservation and stability of the shipwreck. Finally, two general principles are presented that challenge disaster-and-degeneration assumptions regarding underwater sites.

CHAPTER II: 8SL17: THE DOUGLASS BEACH SITE

LOCATION

The Douglass Beach Site is located on the east coast of Florida 3 1/2 miles south of Fort Pierce Inlet at 27°25'03"N and 80°16'03"W. The site is situated offshore Hutchinson Island, a 21-mile-long coastal barrier island, in depths from 2 to 6 meters (see Figure 1).

THE DOUGLASS BEACH SITE: DISCOVERY AND PRIOR WORK

The first evidence of Spanish materials near Douglass Beach was discovered in the 1940s. In 1940-1942 Charles Higgs conducted a surface survey of the general area in an attempt to correlate archeological sites with historical events. Higgs located a barrier-island prehistoric site south of Sebastian Inlet that produced Spanish and Indian artifacts and K'ang Hsi (1662-1772) Chinese porcelain (Higgs 1942:32-33).

In 1946 Hale Smith partially excavated the Higgs Site (Smith 1949). In addition to more Chinese porcelain, he recovered aboriginal Mexican wares, Spanish majolica (dated 1543-1723), 17th-century Delftware, bottles, glass, iron spikes, cannon and English pipes. Smith dated the site between 1696-1725 and considered the 1715 Spanish Plate Fleet a possible source for the artifacts. As evidence, he included a tracing of a 1774 map by Bernard Romans that located 1715 shipwrecks near the Higgs Site (Smith 1949:25). Romans' map was also included in a later report on a regional archeological survey (Rouse 1951:59). (The Higgs site is probably related to Spanish salvage activities.) Kip Wagner, a building contractor and beachcomber, is credited with relocation of the 1715 Spanish Plate Fleet. In the 1940s Wagner began finding Spanish coins on the beach and believed they were washing up from offshore (Wagner 1966:32-42).

After learning of the 1715 plate fleet loss, Wagner observed that all his coins predated 1715. He sent a coin to Mendel Peterson of the Smithsonian Institution and inquired about the 1715 fleet loss. Peterson replied that the 1715 fleet had gone ashore 150 miles to the south in the Florida Keys. The negative response prompted Wagner's interest in historical research to determine his coins' origin. Later, a friend of Wagner's located a copy of Romans' map in the Library of Congress confirming the 1715 fleet location (Wagner 1966:44). Apparently both were unaware of earlier archeological publications mentioning and correctly locating the fleet loss.

In 1959 Wagner located a shipwreck offshore and applied to the state for an exploration contract (Burgess and Clausen 1976:89). The next year he assembled a commercial salvage group and signed a contract with the state of Florida, whose salvage law had been enacted in 1958.

In 1964 the Douglass Beach shipwreck site was located. That year Carl Clausen became the first state underwater archeologist. A year later he published a report (Clausen 1965) on Douglass Beach, which remains the only professional report on any 1715 fleet shipwreck. State field agents were placed on salvage vessels in 1966 to monitor operations, collect field data and record field notes.

In 1972 W.A. Cockrell replaced Clausen as state underwater archeologist and began excavating a submerged Paleo-Indian site at Warm Mineral Springs (Cockrell 1973; 1974; 1980). From 1973-1977 I was Cockrell's assistant.

During the yearly fieldwork at Warm Mineral Springs, field agents who monitored commercial salvage vessels received training in archeological field methods. Cockrell, who recognized the possibility of submerged sites beneath shipwrecks, attempted to enhance data collection on the 1715 shipwrecks.

Cockrell was concerned with provenience of shipwreck materials. The positioning and plotting methods used prior to 1972 were so imprecise as to render scarcely usable data. After 1972 the state updated salvage-vessel positioning by replacing compass bearings, which are too coarse for accurate plotting, with double horizontal angles, first taken with an Ilon Position Finder (a device for taking horizontal angles that is calibrated only to the nearest quarter-degree), and later with sextants. The shore-based targets that were used for the horizontal angles were surveyed and mapped for the first time in 1976. Cockrell and Murphy (1978a) devised a mapping system employing large-scale maps that included clear overlays for different artifact categories. A three-arm protractor was used to rapidly plot the position of each excavation on the site maps.

We chose Douglass Beach for the first base map because prehistoric artifacts and fossils had been recovered there, and we believed that an inundated site was a possibility. We conducted a review of past field notes and plotted artifact locations for 1972-1975 (Murphy 1976). This study revealed the site had been excavated less than we thought and had produced a few fossils and non-fossil bones.

For the first time in 1976, field agents assigned to accompany the 1715 wreck salvors were instructed to recover all faunal and prehistoric material. The 1976 excavation produced four bone pins and 15 bones, including Pleistocene horse teeth. These recoveries increased interest in 8SL17 as a possible inundated terrestrial site. In the past, other evidence had pointed to the possibility of a submerged site at Douglass Beach, but it had been ignored. Megafaunal remains had been reported, and a tooth recovered (Florida Division of Archives site files). I observed megafaunal remains at the site in 1973. A human cranium and projectile points were recovered in the 1960s, but these materials were not relocated by the state archeological conservation laboratory until the mid-1980s.

Realizing the Douglass Beach Site's importance as a submerged terrestrial site, Cockrell attempted to close it to further commercial treasure salvage upon the expiration of the original salvor's lease in 1977. Unfortunately, no legal means existed to prevent commercial exploitation of Douglass Beach because of state salvage regulations; the site could not be permanently closed. As an alternative, Florida granted a salvage permit to a company on condition it fully cooperate with an on-site archeologist. In 1978 I was hired by the state of Florida as project archeologist for two months of excavation at Douglass Beach and verified the presence of an inundated terrestrial site (Cockrell and Murphy 1978a,b).

METHODOLOGY OF 1978 INVESTIGATIONS

The 1978 Douglass Beach Site excavation and survey took place between June 21 and August 13. On 46 working days, salvors used two salvage boats to dig 932 holes of varying sizes and depths, mostly as contiguous holes that formed short trenches. A new "hole" was recorded for each movement of the salvage vessel. A state field agent was aboard each salvage vessel. Sextants were used to position excavation vessels, and horizontal angles were taken from three large targets on the beach. A scaled base map was updated whenever the salvage boat was moved. The boat was normally moored stern to shore, with sextant sightings taken above the screw and water depths taken with a weighted tape.

A prop-wash deflector, the common method of commercial wreck salvage in Florida, was used for all 1978 excavations. The deflector, or "blower," is a right-angled, transom-mounted device somewhat larger in diameter than the vessel's screw. It is pivot-mounted so it can be lowered to direct the prop backwash downward. During excavation the vessel is secured in a three- or four-point moor with the deflector in position. When the engines are engaged, a powerful column of water is forced through the deflector to blow a large, circular hole in the sea bottom.

Once a hole is opened, the engine speed can be decreased and the hole will remain open. A new hole can be dug, the hole enlarged or moved in a specific direction by mooring line adjustment. Digging speed, as well as hole size and depth, can be changed by altering engine revolutions.

A serious limitation of the deflector for archeological applications is that it is difficult to control. The powerful prop wash rapidly displaces or disintegrates cultural materials, precluding stratigraphic excavation. Usually stratigraphy is observable only in the sloping sides of the hole. Even when the engine is idling, the water volume is often excessive for shallow-water excavation. Hull movement unevenly erodes the hole, which tends to collapse as soon as the prop wash stops.

In 1978 I placed restrictors of various materials over the prop-deflector intake to minimize the water flow reaching the bottom in an attempt to overcome some of the device's limitations. Restrictors, together with very small mooring line shifts, made possible stratigraphic observation and sample collection.

I observed that when a particular grey, fragile, sandy stratum was present, any Spanish coins located there were always found directly above it. This stratum was easily distinguishable from the overlying marine sediments. The grey stratum was rapidly eroded by the downwash, and was visible briefly during initial excavation or in the side of a stabilized hole. When the mooring lines were shifted, the stratigraphy could be examined in the newly eroding portion of the hole. With careful mooring line adjustment, a trench could be dug in the bottom.

Three zones were recorded beneath the marine sand: Zone 3, a 25-centimeter-thick grey, sandy layer directly beneath the marine sediments; Zone 2, a loose, sandy layer about 20 centimeters thick; and Zone 1, a resistant, hard-packed, sandy layer containing many strata. The overlying marine sandy sediments averaged between 1 and 2 meters, and the water depth was 4 to 5 meters.

With experience, it became increasingly easy to discern the top two strata. When excavating the northwest portion of the site, the upper stratum's absence indicated the area had been previously dug. Often a deep hole dug by past salvors well into Zone 1 stratum was encountered that yielded coins and artifacts that had been overlooked in the old hole bottom.

Most undisturbed strata were located just inshore from a shallow reef area within 200 meters of the beach (Figure 5, Chapter 4) in the northwest portion of the site, where the majority of the bone pins and faunal material were discovered (Figures 5 and 6). (The bone pins recovered in 1976 were also from this area.) As the bathymetric contours indicate (Figure 5), undisturbed areas were inshore of a 3-meter-deep reef line and at a depth of 3-4 meters. No Zone 3 or Zone 2 strata were reported seaward of this reef.

In undisturbed areas, excavation proceeded slowly, and as carefully as the restricted deflector allowed. During the two-month project, 28 field samples were collected, primarily from the northwest site area. Two macrobotanical specimens from Zone 3 were collected at different times from just beneath the marine sediments to establish the date of the underlying sediments (see Radiometric Dating below).

A 2-inch-diameter core from Zone 1 was taken from an undisturbed area in the northwest part of the site (Figure 1) to aid in determining the stratigraphy of that zone. To collect the core, a hole was opened through Zones 3 and 2. The core was pounded into the bottom sediments with a sledge hammer, capped and dug out with the deflector. Twenty-five inches of sediments were extracted in the core (Figure 4, Chapter 4). The core was split, examined and stored. Bulk samples of Zone 1, 2 and 3 were collected in the vicinity. Soil samples were stored and analyzed for pollen, geochemistry and sedimentary constituents in 1988.

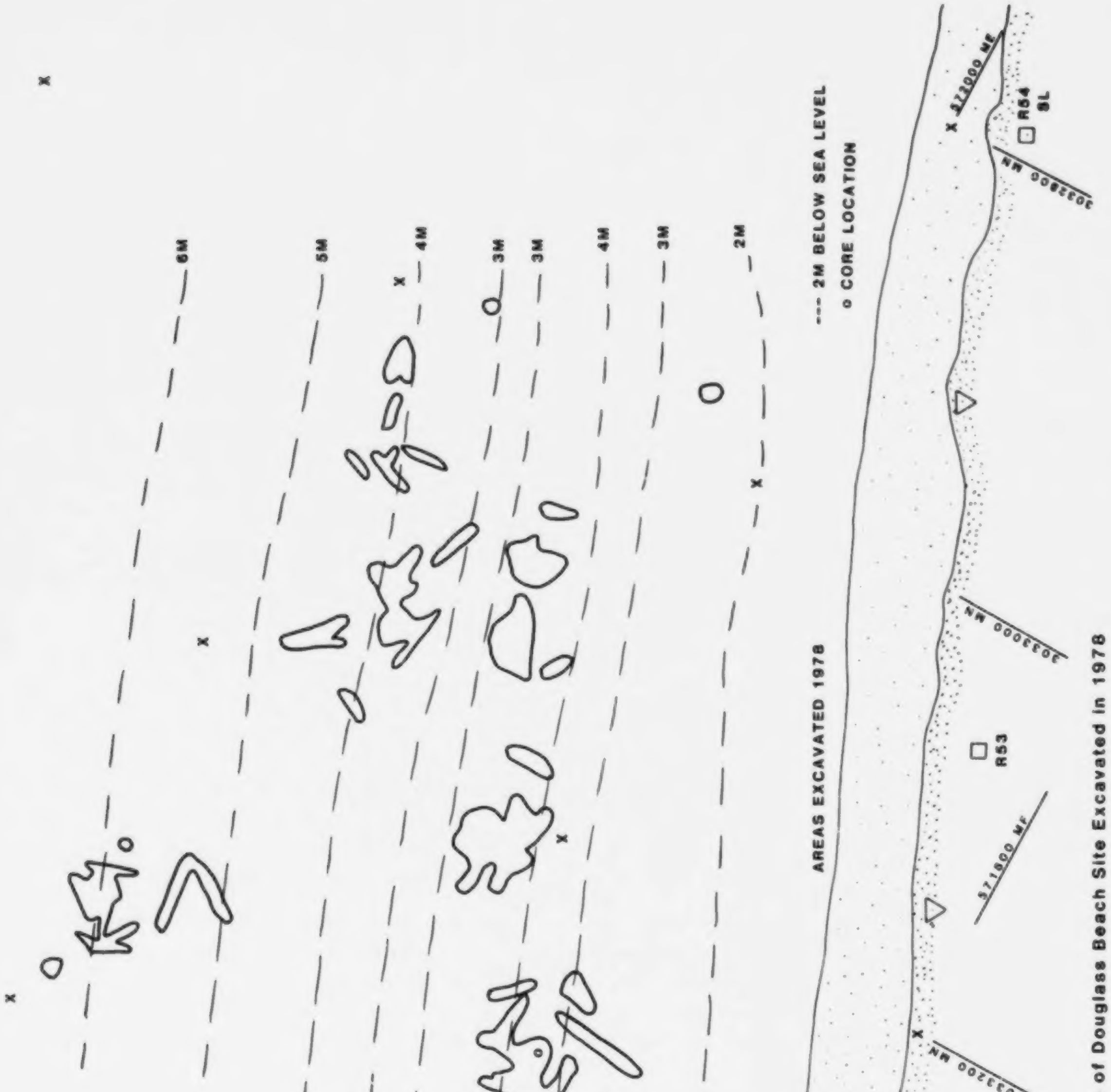

DOUGLASS BEACH
8SL17
MSL
DUNE LINE
AREAS EXCAVATED 1978
--- 2M BELOW SEA LEVEL
o CORE LOCATION
6M
5M
4M
3M
3M
4M
3M
2M
R52
SL
R53
R54
SL
3033400 MN
3033200 MN
3033000 MN
3032800 MN
371600 ME
372000 ME
FLORIDA
LOCATION
100
50
0
100

Fig. 1. Areas of Douglass Beach Site Excavated in 1978

CHAPTER III: GEOLOGY AND COASTAL PROCESSES

GEOLOGY

The primary geological formation in the area is Anastasia Formation, which is common along Florida's east coast from the type-site location of Anastasia Island near St. Augustine to just north of Miami, where it grades into the Miami oolite limestone formation. Anastasia lithology varies from coarse rock to sand, and shelly marl to sandy limestone, with mollusks typically associated. Often the formation consists of broken shells cemented by calcium carbonate and iron oxide (Cooke 1945:266). Iron oxide streaks, sometimes erroneously attributed to the presence of shipwreck materials, are frequently observed in this formation.

Originally "Anastasia Formation" was applied only to coquina rock, but it now includes all Pleistocene marine deposits (Cooke 1945:265). The deposit is estimated to be more than 100 feet thick (Puri and Vernon 1964:282).

Offshore deposition from features such as bars, ridges and elevated dunes account for uneven formation. Anastasia contains peat and clay deposits (some of which were observed during site excavation about 200 meters offshore) from lagoonal deposition on landward sides of sand bodies (Missimer 1984:394). Anastasia Formation comprises the exposed reefs offshore Douglass Beach and underlies Holocene sediments.

Once believed to be early Pleistocene in age, Anastasia is more recent, forming during many periods during the Pleistocene (Brooks 1972). Observations made during shipwreck excavation indicate Anastasia may still be forming. Above Anastasia is "worm rock," composed of Seballarid worm deposition.

COASTAL PROCESSES

The principal natural forces affecting Douglass Beach archeological remains are waves, longshore drift, sea-level change, barrier-island formation, migration and erosion. Understanding these remains requires investigation of coastal processes.

Waves and Currents

Complex interaction of waves, wind, tide and current determines coastline morphology. Waves hitting Douglass Beach have an uninterrupted fetch of thousands of miles, which is one reason the area is considered a high-energy environment. Wind is the major wave producer. An average of 26 percent of annual winds blow from the north or northeast, where the intensity is greatest; 48 percent of annual winds come from the east, the south or southeast. Winds from other directions have a quieting effect on the waves. Most waves between 4 and 8 feet high come from the north-northeast, those exceeding 12 feet mostly come from northeast. Average annual wave height is 2.1 feet (U.S. Army, Corps of Engineers nd.:C-5-6). The northern wave propagation creates a net southerly littoral drift.

The mean semidiurnal tides at Fort Pierce Inlet are 2.6 feet, with spring tides of 3.0 feet. Severe onshore winds can raise tides an additional 3 to 4 feet. High wind velocities coupled with low barometric pressures, such as those accompanying tropical storms, have pushed the tides as high as 13 feet above normal (U.S. Army Corps of Engineers nd.).

Storm surges associated with high tides and large waves can be very destructive to coastal areas. Storm conditions create strong longshore currents that can totally erode sand bars and low-lying dunes in hours and breach barrier islands.

Hurricanes and "northeasters" are major storms common to the research area. Hurricanes usually occur between August and October, with a 20 percent chance of a tropical cyclone (winds in excess of 119km/hr) hitting Douglass Beach in any given year (Gentry 1984:511). Northeasters, which occur annually during the winter months, erode the shoreline. Eroded beach sediments are normally replaced during the summer.

Wave impact is typically seen as an overwhelmingly destructive force to submerged sites. There has been little investigation of actual wave impact to archeological sites, and common-sense ideas have prevailed. An extensive wave-process investigation is beyond the scope of this report, but some relevant aspects and observations will be discussed, drawing primarily from Bascom (1980).

As ocean waves and swells enter shallow water, their systematic circular wave motions become turbulent in the surf zone. Bottom sediments are put into suspension by wave action. The relative size of particles put into suspension and the length of time they remain so is a function of particle size and weight and the energy of the wave. Simply, bigger waves can suspend bigger particles. When the turbulence diminishes, heavier particles come out of suspension first. The depth below the sea bed of sediment disturbance, called the wave base, is directly related to wave height.

Wave suspension and transport of sand causes beach erosion and littoral drift. Wave steepness (the height-to-length ratio) is important for sediment transport. When the wave is not steep, sand is moved toward shore; when steep, the shore may erode, forming an offshore bar while building up the shore berm. These processes take place on the sand-grain level, with a suspended grain moving a short distance before dropping, while others are picked up and moved a bit farther. The net transport, which takes place mostly at the top of the seabed, may be large, but each grain is moving only a short distance at a time.

These processes have two important implications for coastal and inundated sites. First, heavy wave action erodes beach and dune sites and displaces lighter materials in the direction of littoral drift. Denser materials tend to remain in place, for there is a size and weight limit for materials that are transportable under a certain set of conditions. Second, any site buried beneath the deepest wave base will not be disturbed by wave turbulence.

Implications for shipwrecks are similar. Although larger and heavier materials can be moved by wave action, they tend not to move much, but drop more or less vertically to the wave base. A shallow sea during a storm can be visualized as a sand/water mixture, mostly water near the surface and mostly sand near the sea bed. The mixture becomes denser (more sand particles per volume of water) toward the wave base. The solid bottom is the wave base, the repository for all materials too large or heavy to be put into suspension. As the storm subsides and wave action diminishes, particles come out of suspension and bury the heavy materials at the wave base, a process observed in heavy seas near Douglass Beach.

Some shipwreck materials deposited in a storm, or later subjected to storms, may become differentially sorted. Materials much heavier than the suspended particles will move vertically down through the sediments until their weight is supported by the bottom sediments. A dense artifact will quickly settle to the wave-base level and be buried by increasingly lighter sediment as the storm subsides. Materials with a high specific gravity drop quickly to the wave base to be buried and do not "wash up" on the beach as do light, buoyant materials. Coins found by beachcombers are the result of human, not wave, activity. The only conceivable way coins and other dense materials could reach the beach without direct human action is by floating ashore on something buoyant.

Differential sediment sorting was observed during the excavations at Douglass Beach. The uppermost seabed stratum was composed of relatively fine material. Within the marine sand, layers of coarser materials, which represent wave base levels of recent storms, could be observed. Coins, ferrous artifacts, and beach rocks, when found in unexcavated areas, were located directly above a 5000-year-old stratum. The top of this stratum represents the maximum wave-base depth since 1715. The coins and artifacts have not moved about, but have been laterally stable. Further evidence for shipwreck-artifact stability is the lack of sand wear on gold coins and jewelry from 1715 shipwrecks (personal observation, Florida artifact collections). A recent examination of the state's collection of 1401 gold coins revealed only two with evidence of sand wear (Craig 1988:35).

Sea Level

Sea-level fluctuation is a critical component for reconstructing paleoenvironment, prehistoric populations and subsistence patterns in North America. Sea level varied widely between 14000 and 2000 B.P., a period that includes Paleo-Indian and Archaic periods. The Douglass Beach prehistoric component was deposited during a lower sea level and altered by transgressive seas. A discussion of sea level relevant to archeological interpretation in Florida, where the importance of sea level was first realized, follows.

The most recent changes in sea level reflect alterations in the volume of water in the earth's oceans relative to the volume held in glaciers (Antev 1928; Flint 1957; Donn et al. 1962), as well as alterations in circulation patterns and thermal regimes. The inverse ratio of sea-to-glacial-water volume, and corresponding alterations in sea level (glacio-eustatic level), are used as a basis to infer changes in paleoenvironments, subsistence and settlement patterns (Cockrell 1980; Belknap 1983; Kraft et al. 1983; Masters and Flemming 1983; Flemming 1985).

Late Quaternary sea-level curve formulation is important to the study of continental shelf inundated sites. Because sea level determines coastlines, lower sea levels exposed large continental shelf areas (e.g., Emery 1958; Ballard and Uchupi 1970; Cockrell 1980; Belknap 1983) and made them available for human habitation. Any complete model of the interrelationships of North American human groups, environment and long-term changes must consider sea level and currently drowned continental shelf areas.

Sea-level effects are particularly notable in Florida because of the gradual continental shelf slope on the southern and Gulf coasts. The Gulf sea level during the last glacial maximum (about 18000 B.P.) was on the order of 160 meters below present level (Ballard and Uchupi 1970), which would double Florida's land mass.

In 1940 sea-level rise was first demonstrated in Florida, and was incorporated into archeological interpretations in 1948 by John Goggin (Goggin 1964a:98). In 1959 Goggin, an early pioneer in underwater archeology, suggested " . . . the shore lines during glacial advances are now under many feet of water. For some periods of man's cultural history there may well be far more data under the sea than on the land" (Goggin 1964b:305-6). Goggin's statement is probably the first formulation of the hypothesis that inundated terrestrial sites would be located offshore. Some of the first drowned-site evidence was discovered that same year off the California coast by divers who recorded stone mortars underwater (Shepard 1964).

In 1966 Emery and Edwards established a relative sea-level curve and discussed archeological implications (Emery and Edwards 1966:734-5). They noted both Paleo-Indian and Archaic habitations were likely submerged offshore, and sites of a particular period could be located at specific depths.

In 1968 Ripley Bullen located a 2700 B.P. site on the barrier island beach south of Sebastian Inlet just north of Douglass Beach (Bullen et al. 1968). The top of the site was 2.5 feet below the high-tide water level. This site was the first located on the East Coast that demonstrated clear evidence of a lower sea level. Bullen noted the similarity of sea-level variation to the Gulf coast sites (e.g., Bullen and Bullen 1950) and concluded the possibility of Paleo-Indian and Archaic offshore sites (Bullen et al. 1968:15; Bullen 1969).

Pleistocene faunal remains have been recovered from the Atlantic shelf (Richards 1938; Whitmore et al. 1967; Emery 1969), and artifacts have been found in the Gulf of Mexico (e.g., Goodyear and Warren 1972; Warren 1972; Goodyear et al. 1980). Goodyear (et al. 1983) reported 27 Paleo-Indian points dredged from Tampa Bay. It is possible to determine sand abrasion microscopically (Shackley 1974), but Goodyear does not mention such analysis. If there is no sand wear, which indicates movement, then the artifacts may represent subsistence activities rather than redeposited materials.

Emery and Edwards (1966:734; 736) pessimistically remarked that little might remain offshore beyond "some tools," because of the advancing seas and "the scattering of materials produced by the passage of the surf zone over the sites." This perspective, a good example of the disaster-and-degeneration view, has been mirrored by later investigators, and contributes to the low interest in offshore inundated sites.

The primary geological question of relevance to Douglass Beach is the establishment of a curve that accurately represents the past shore position relative to the present level. Recent sea-level research will be discussed to develop a general pattern for the Southeast.

The Southeast is assumed to have been geologically stable for the last 12,000 years (Blackwelder 1980; Redfield 1967), consequently isostatic changes will not be considered. Mid- and South-Atlantic coastline stability has been questioned (Clark 1981; Dillon and Oldale 1978:58, although they assume a stable Florida west coast).

Sea level may have been 25 feet higher than present at 100,000 B.P. (Hoffmeister 1974:25). Glacial advance lowered the sea level to the present level between 35000 and 25000 B.P. (Curray 1960,1965; Milliman and Emery 1968). As glacial advance continued, sea level receded to 120-160 meters below current level. The minimum sea level has been debated. Curray (1965) and Milliman and Emery (1968:1121) indicate 130 meters below present level at 16000 B.P., whereas Blackwelder et al. (1979) and Oldale and O'Hara (1980) put the level above 100 meters. Some researchers question any attempt to establish a sea-level curve below 60 meters with current data (e.g., Emery and Merrill 1979; MacIntyre et al. 1978).

There has also been disagreement as to when the maximum ice advance occurred. Some geologists place maximum glaciation (and lowest recent sea level) about 20000 B.P. (e.g., Curray 1965; Emery and Garrison 1967; Shepard 1963a; Blackwelder et al. 1979), but others place it at 15000 B.P. (Emery and Milliman 1970; Emery and Merrill 1979; Newman 1977). In either case, Paleo-Indian and Archaic periods were characterized by a changing environment and transgressive seas. The significance to Douglass Beach and other offshore sites is that the surf zone has passed over all coastal areas, complicating geoarcheological interpretation.

Glacial meltwater from a general climatic warming beginning about 14000 B.P. (Milliman and Emery 1968:1121) rapidly raised sea level to within 10 meters of the current level. The rate of rise slowed, with the present sea level reached between 2000 and 4000 B.P. Archeological evidence in Florida (Bullen 1950, Bullen et al. 1968) supports the recent date. Sea level has continued to rise (Shepard 1964; Redfield 1967); the last century's rise attributable to thermal expansion of the oceans (Gornitz et al. 1982).

General eustatic sea-level rise has been noted world-wide; many regional curves are congruent, with local variations observed (Guilcher 1969). However, caution must be used when accepting the levels measured for any single coastline as indications of global levels (Emery and Garrison 1967:687).

Although there are some varying opinions regarding the nature of sea-level rise in the last 6,000 years (e.g., Fairbridge 1960, 1961; McFarlan 1961), the consensus is that transgression slowed, but has continued to rise to the present (Shepard 1963a,b; 1964). No evidence for Florida clearly reflects a level higher than current (Coleman and Smith 1964:833), nor a long still-stand at a lower level (Scholl et al. 1967).

Two general sea-level rise models have been offered: a smooth, continual rise and a fluctuating curve. Smooth curves have been generated by most researchers (e.g., Shepard 1963a, 1964; Milliman and Emery 1968; Curray 1960, 1965; Coleman and Smith 1964), with a fluctuating curve represented by Fairbridge (1960, 1961).

Most sea-level curves are averaged data representations from a wide area. Production of fine-grained regional sea-level curves is more complex, reflecting both local and general fluctuations. Southeast researchers have recently developed regional sea-level curves for the last 6,000 years that are relevant for Douglass Beach.

Southeast sea-level rise follows the general eustatic transgressive curve of rapid rise to 6000 B.P., then slower rise with apparent periodic oscillations on the order of +/- 1 meter evidenced in South Carolina (Brooks et al. 1979; Colquhoun and Brooks 1986:289). One- to 2-meter fluctuations appear to have occurred every 400-500 years (Colquhoun et al. 1981). These fluctuations would have to be glacio-eustatic in origin. They conform to similar sequences reported in the Netherlands (a tectonically stable region, Shepard 1964:575), and are transgressive between 2300 and 2000 B.P., 3300 and 3000 B.P., and 4500 and 4000 B.P. (Colquhoun and Brooks 1986:289; Colquhoun et al. 1980:145).

Compared to the sea-level research in South Carolina, there has been relatively little done in Florida. Published work does not conflict with the South Carolina curve, but does not clearly reflect similar fluctuations. Scholl and Stuiver (1967) produced a smooth curve for Florida generally conforming to the South Carolina curve (Colquhoun and Brooks 1986; Brooks et al. 1986), without cyclic fluctuations. Scholl et al. (1967) used hatching to indicate the area of uncertainty in the dates. The South Carolina fluctuations observed are accommodated within the hatched area.

The sea-level curve used for interpretation of Douglass Beach is in Figure 2. The recent Southeast sea-level curve, as shown in Figure 3, is the model for changes within the last 6,000 years.

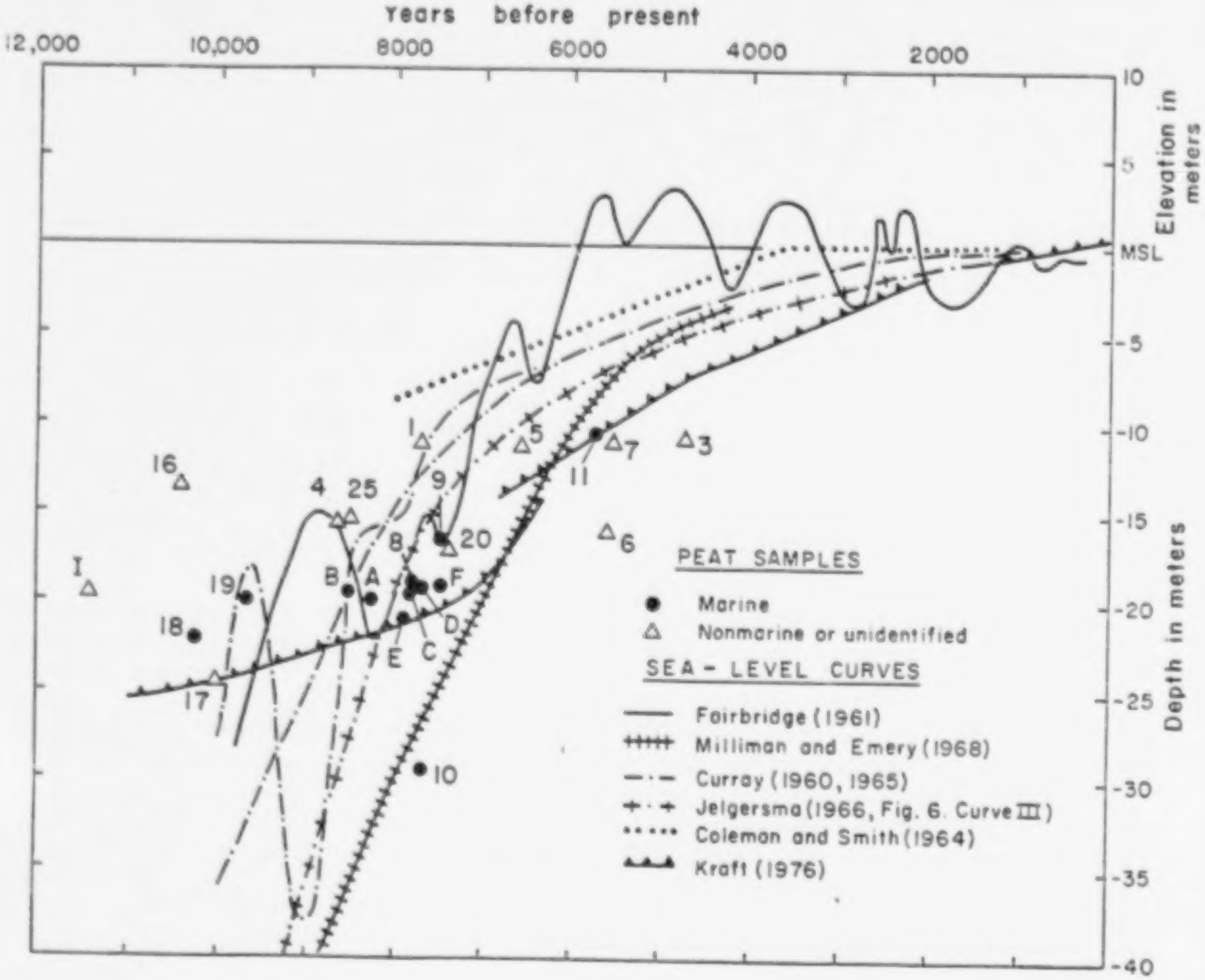
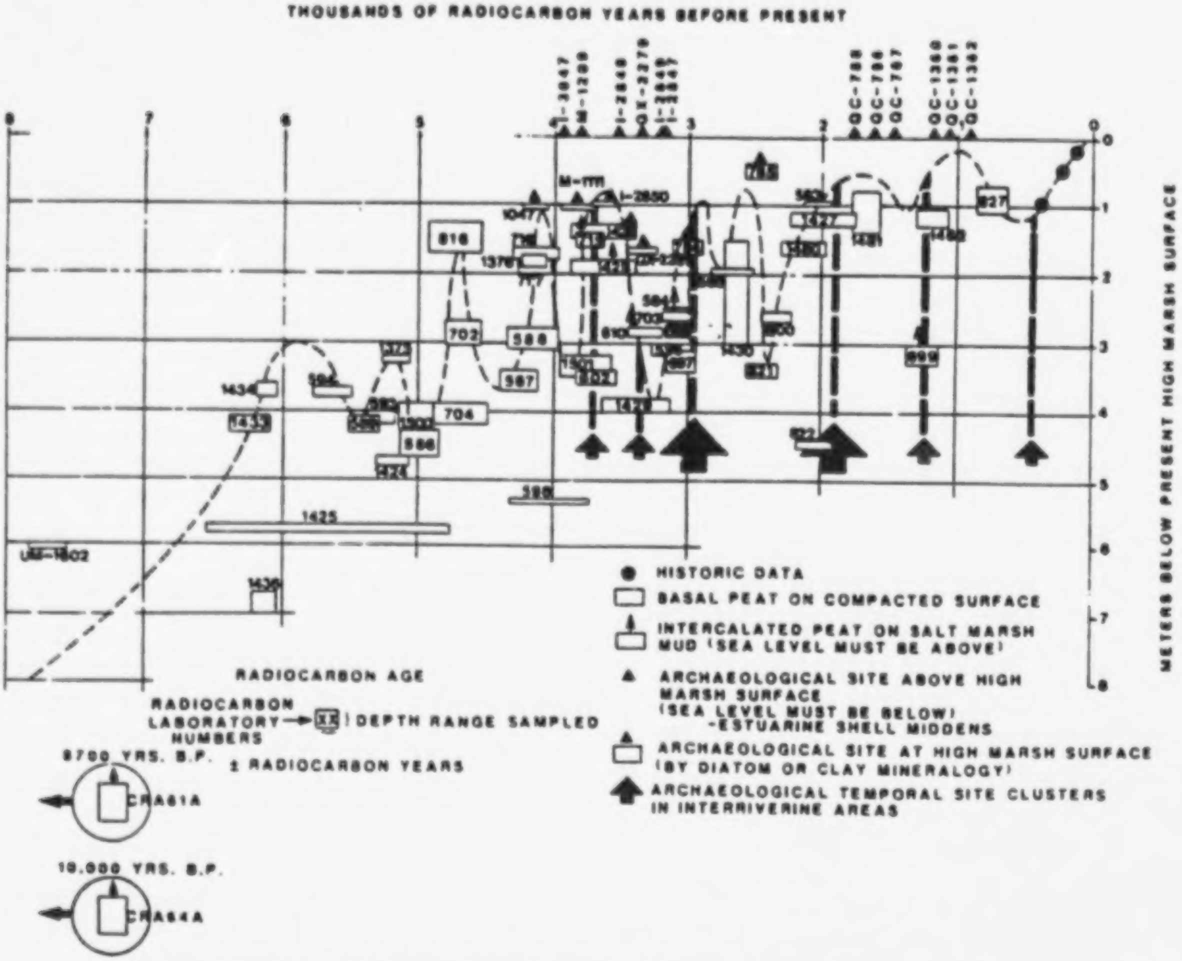


Figure 2. General Sea Level Curves (from Field et al. 1979:626)

Sea-level fluctuation in the last 14,000 years has profoundly affected coastal-zone geomorphological and environmental features. The dominant features of the Douglass Beach Site are marshes and barrier islands. An understanding of the interaction of barrier islands and sea level is important in accounting for site preservation and formation processes.



Sea level change curve for the South Carolina Coast. After Colquhoun and Brooks (1986).

Figure 3. Sea Level Curve from South Carolina (Brooks et al. 1986:299).

Barrier Islands

Holocene transgressions radically altered the coastal zone as the rising sea crossed the outer continental shelf, averaging 150 km in width. The transgression caused a landward migration of shoreline features. Upland areas sequentially became fringing marsh, marsh became lagoonal, lagoonal areas became beach ridges, and beach became sea bottom. The varying transgression rates differentially altered coastal features, complicating local archeological interpretation. Delaware, for example, retreated at 20 meters/year at 10000 B.P., 5 meters/year at 5000 B.P., and at present has a 1.5 meters/year retreat (Belknap and Kraft 1981:429). Retreat rates can be estimated from the steepness of the local sea-level curve and the shelf profile gradient.

Because the dominant Douglass Beach coastal feature is the barrier island and lagoon complex, barrier-island development and migration are discussed to examine their role in site formation and preservation. Because the processes responsible for the preservation of the Douglass Beach prehistoric component may be uniformitarian, the results will be significant wherever barrier islands exist, including submerged offshore. Because barrier islands are common, large and easily recognizable features, they can contribute as a basic element in an elaborated continental shelf site-location model. Barrier islands with their characteristic linearity, anomalous elevation and sedimentary profiles could become signatures of preserved strata during remote-sensing surveys and coring operations.

The possibility that barrier-island migration may affect archeological sites was suggested by Bullen in 1968 when he was excavating the Cato Site on the Atlantic coast near Vero Beach (Bullen et al. 1968:15). The elaboration of this insight has been a central concern of the Douglass Beach Site research.

Barrier islands, barrier spits and associated marshes are distributed extensively worldwide, currently found on 9 percent of the world's coastline (Leont'yev and Nikiforov 1965:61). Some of the largest barrier islands are in North America, and the features are nearly continuous on both the Atlantic and Gulf coasts. The 2,000-kilometer coastline between New York and Miami contains 121 barrier and sea islands that form 21 percent of the United States estuarine environment (Hayden and Dolan 1979:1061).

Origin of Barrier Islands

A model of barrier-island origin extends the Douglass Beach observations to other areas. The basic question is whether barrier islands formed only in their present location or also during lower sea-level stands. If they formed during lower stands, remnant barrier features may be considered a priority for archeological survey.

The exact origin of barrier islands is not well understood, primarily because they seem to be formed in different ways (Schwartz 1971; Field and Duane 1976; Hayden and Dolan 1979). Four formation mechanisms are postulated: upbuilding of marine bars; segmenting of elongating spits by inlets; submergence of mainland coastal beach ridges (Field and Duane 1976:692); and submarine barrier emergence during a short-term sea-level fall (Leont'yev and Nikiforov 1965).

The drowned-beach ridge theory (e.g., Hoyt 1967) suggests barriers are formed subaerially during a lower sea-level stand and later submerged. The spit-formation theory maintains barrier islands begin as spits built up by longshore currents carrying sediments from eroding headlands. Inlets then segment elongated spits to form barrier island chains (Schwartz 1971). Otvos (1970) provides evidence that Gulf Coast barriers form by upward aggradation of submerged shoals during sea-level rise. Little evidence exists to support a longshore drift origin of barrier islands (Field and Duane 1976:693). Barrier islands are typically formed from sea-floor material and require large unconsolidated sediment reserves on a gentle submarine beach gradient. A submarine bar is incapable of becoming an exposed feature without a brief fall in sea level that exposes the top of the feature and allows the accretion processes to begin (Leont'yev and Nikiforov 1965:63).

Geological fieldwork and sedimentary analysis have provided support for each theory in various places. Consequently, it is apparent that barrier islands have multiple causality (Schwartz 1971). The four theories also indicate that barrier islands form during periods of sea-level rise as well as during brief regressions.

It is generally agreed that present barrier islands formed during the last 5,000 to 6,000 years (Dolan et al. 1980:18). A question exists as to whether they formed in their current position, or were formed at a lower level and migrated to their present location. The general formation process seems to be a heavy sediment load pushed by transgressive seas. The base of many current barriers is 5-10 meters below sea level, the level of transgression slowdown at 5000-6000 B.P., when sea-level fluctuations are recorded (Brooks et al. 1986:299). This congruence could be coincidence, however. Field and Duane (1976) provide evidence of transgressive barrier-lagoon complexes over much of the inner continental shelf, and they argue that barriers forming in place only in the last several millennia would require a set of special conditions counter to the principles of uniformitarianism (1976:698).

Investigations of barrier-island sediment origin supports Field and Duane's theory. The sediments forming North American barriers were partially supplied by ancient Pleistocene barriers (strandlines) deposited at times of high interglacial sea level (Kraft 1971; Belknap and Kraft 1981). Sufficient unconsolidated sediment was available to supply barrier systems from a depth of 80 meters during the last transgression. Consequently, wherever there are sufficient sediments, barrier islands could have formed on the continental shelf shallower than 80 meters.

Presence of abandoned strandlines left from the pre-Holocene recession is important because they may have been utilized by humans prior to inundation. The present continental shelf has been composed primarily of marine and coastal sediments during all times of human access. In the case of Florida, the sea level prior to 100,000 B.P. was higher than present and has passed over the current coast and nearshore areas during the last recession. Prior to the postglacial rise in sea level, the continental shelf was composed of sediments from the post-100,000 B.P. regression. Consequently, Paleo-Indian and Archaic occupation areas, even when far from the occupational contemporary shore, will be associated with marine coastal sediments and geomorphological features. Implications are that continental shelf archeological sites will require a thorough understanding of long-term coastal processes to sort out early site-formation processes.

Migration of Barrier Islands

Unlike the dispute on barrier-island formation mechanics, there is little disagreement that barrier islands are mobile features and that most North American barrier islands are migrating landward. Much evidence exists to support the latter observation, including peat, stumps and lagoonal facies located seaward of ocean beaches (e.g., Blackwelder et al. 1979; Burgess 1977; Curray 1960; Dillon and Oldale 1978; Emery and Merrill 1967; Emery et al. 1967; Field et al. 1979).

One of the most important barrier-island migration processes is subaerial sand overwash into the back-barrier lagoon or marsh. During severe storms, high waves and surge tides combine to top the island and wash a sediment layer onto the backside of the lagoon. The shape of the barrier may be altered, but there is a general conservation of sediment. The cumulative effect is movement from the seaward side of the barrier to the landward side; a net landward movement seems to be the primary migratory process during rising sea level (Field and Duane 1976:693).

In addition to overwash, inlets cut through barrier islands. Inlet movement can rework the sediments and stratigraphy of barrier islands (Hoyt and Henry 1967:82). Barrier islands can be recognized by their associated sediments; however, because of shore processes related to migration, portions of the record may be removed, inverted or obscured in localized areas (Hoyt and Henry 1967:84).

As the barrier island retreats at the front of rising sea level and moves across back-barrier lagoonal and marsh deposits, the seaward face of the island can be eroded (Swift 1968). This shore-face erosion is usually seasonal. Seasonal variation at Douglass Beach is winter erosion and summer accretion.

Belknap and Kraft (1981:430) note that inlet, lagoonal and estuarine sediments are more likely to be found preserved on the outer continental shelf; barrier and dune sediments are somewhat less likely to be preserved.

Preservation of Barrier Islands Offshore

Because barrier islands have formed whenever certain conditions are met, and are moved by transgressive seas and differentially eroded, inundated barrier remnant features may be found on the outer continental shelf. Curray observed that certain submerged ridges "probably represent old barriers and spits only partially flattened during the [most recent] transgression" (Curray 1960:263). There is sedimentary evidence that barrier islands have existed in many places on the shelf and migrated shoreward during the Holocene transgression (Field and Duane 1976:701).

Paleobarriers have been located off the New Jersey coast in 20 to 40 meters of water (Stubblefield et al. 1983). These barriers were believed formed between 8000 and 14000 B.P. The model developed proposes that when rapid sea-level rise exceeded the amount of available sediment needed to maintain the barrier islands, they became submerged. Initial erosion removed the dunes and upper levels of the island, leaving the lower portions. Sanders and Kumar (1975) and Rampino and Sanders (1980) discuss drowned barriers off the coast of Long Island and cite evidence for a 5-kilometer jump of the transgressive Holocene shoreline from the seaward side of the barriers to the landward edge of the lagoon. The shoreline jump eroded the barrier dunes and left lower sediments preserved.

Belknap and Kraft (1981) demonstrate that sea-level rise rate is a dominant factor in outer-shelf feature preservation. Better preservation is found in water depths of 80 to 140 meters than the nearshore areas. However, although they note that the nearshore zone may have been "planed" by a slower sea-level rise, there are cases of lagoonal, tidal inlet and delta, and some barrier facies preservation. In general, they note that "the more rapidly the shallow offshore is placed below wave-base, the lesser the destruction of the stratigraphic column" (1981:434,436).

It is clear that barrier islands move through a process of overwash that deposits subaerially exposed sediments onto the back-barrier features. This layer of sand builds up and shields the lagoon-related sediments--and any related archeological site--from direct exposure to shoreface erosion. As the barrier island moves shoreward, pushed by rising sea level, the lagoonal sediments can be preserved. By the time the barrier island passes completely over an area, sea level has risen, tending to place some back-barrier lagoonal sediments below the active marine wave base. This process can potentially preserve inundated terrestrial sites in a high-energy environment.

The recognition of barrier-island processes coupled with demonstrated preservation of inundated relict barrier-island features augments the current site-location model for prehistoric sites on the continental shelf. The paleo-barriers with associated lagoonal sediments beneath them should be considered high-probability areas for future continental shelf archeological surveys. The Douglass Beach Site demonstrates archeological site preservation by this process.

CHAPTER IV: ANALYSIS AND RESULTS

RADIOMETRIC DATING

Five radiocarbon dates have been generated for 8SL17. Three samples were recovered in 1978 and dated in 1982: a peat sample from the beach inshore of the site, and two wood samples hand-collected underwater from the stratum immediately below the marine sediments (Zone 3, which is equivalent to sample 6 in the sedimentary and geochemical analysis [Figure 4]). The two underwater samples (FS 85 117-FS-720 and 729, both collected by the author) were dated by Teledyne Isotopes of New Jersey (sample number 720 = I-12,763; Number 729 = I-12,764). The peat sample (FS 85 117-Sample 3, Bottom, Sta. 1, I-12,765 collected by W.A. Cockrell) came from a shoreface stratum exposed by a storm.

All samples were treated for removal of carbonates and humic acids and the dates were based on a half-life of 5,568. The dates were: Sample 720--4880 +-100 B.P.; Sample 729--5080 +-110 B.P.; Peat--1000 +- 80 B.P. The two underwater samples establish the date for the youngest sediments beneath the marine sand overburden. The peat date marks the youngest back-barrier sediment encountered on the marine shoreface of the barrier island. The peat date provides a measure of recent island migration because peat can only form on the landward side of a barrier island.

The fourth sample was analyzed in 1984, soon after commercial salvors discovered a linear feature consisting of stakes driven into the sediments. A 3 by 20-centimeter sharpened stake that was battered on the end provided a 4630 +-100 B.P. date (I-13, 8410).

The fifth sample, extracted in 1988 from the 1978 core, was a dark, organic-rich layer (core level 3, Figure 4) composed of organic materials, quartzose sand and scattered shell fragments. Unfortunately, the sample contained insufficient organic material for dating, so the carbonate fraction (0.16 grams of carbon) was dated. Except for sample-size difficulties, all analytical steps proceeded normally, and a quadruple count was applied to reduce statistical counting errors. The sample dated at 9110 +- 310 B.P. (28111).

Radiometric analysis indicates that all sediments below the marine stratum are older than 4800 B.P. The core date

(9110 +-310) may be specious because of contamination by older shell overwashed from barrier-island sediment, originally from farther offshore.

The peat sample indicates shoreward migration of the barrier island. The peat formed on the landward side of the barrier island 1,000 years ago; the island's migration since then has exposed it on the seaward shore.

The stake dates the only prehistoric feature discovered. Unfortunately, no archeologists observed the feature.

PALYNOLOGICAL ANALYSIS

Palynological analysis was conducted to determine past floral communities to aid prehistoric subsistence-pattern reconstruction. Pollen analysis also reveals the impact of natural processes. For example, absence of palynologically discrete strata or presence of mechanically damaged pollen marks wave disturbance of the sediments. Modern pollen presence below the marine strata indicates sediment mixing.

Three bulk samples, one each from Zone 3, 2 and the upper portion of Zone 1, along with strata from the core (Figure 4) were analyzed. The analysis results, including sediment description and pollen profile, are reported in Appendix 3 (Cummings 1988).

The core consists of six strata. The dark layer represents a marsh environment. The other layers reflect pine-dominant vegetation, with some hardwoods and salt-tolerant species consistent with regional paleoenvironmental reconstructions.

Environmental reconstruction cannot be reliably based on a single core and three samples. Comparisons cannot be made with adjacent areas because no other pollen samples were taken. Obviously more data are needed to understand environment and settlement changes resulting from a fluctuating, general rise in sea level. Transitions from upland ecology to marsh and estuary, then lagoon and finally to barrier island present a complex reconstruction problem.

However, Douglass Beach Site pollen analysis does demonstrate that reconstruction is possible. Two observations from the pollen analysis are directly relevant to formation processes. First, the pollen analyzed from the bulk samples and all but the lowest stratum of the core was plentiful and well-preserved, with little weathering or mechanical damage. This strongly indicates a low-energy environment, because pollen deposited in high-energy environments rarely survives (Pearson et al. 1986:285-289).

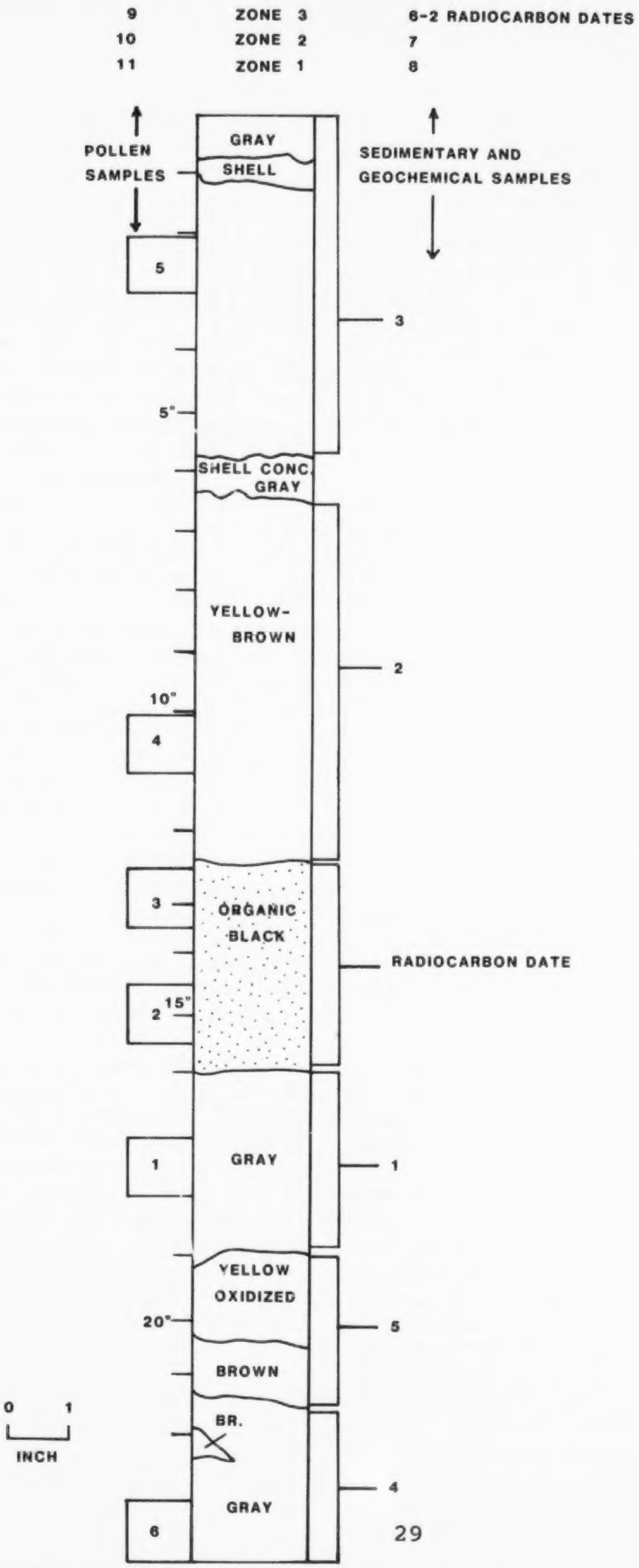

9 ZONE 3 6-2 RADIOCARBON DATES
10 ZONE 2 7
11 ZONE 1 8
POLLEN SAMPLES
SEDIMENTARY AND GEOCHEMICAL SAMPLES
GRAY
SHELL
5
3
5"
SHELL CONC.
GRAY
YELLOW-BROWN
2
10"
4
3
ORGANIC BLACK
RADIOCARBON DATE
2
15"
1
GRAY
1
YELLOW OXIDIZED
20"
5
BROWN
0 1
INCH
BR.
4
GRAY
6

Fig. 4. Core Diagram from Douglass Beach Site

Second, the pollen assemblages were stratigraphically discrete, indicating no mechanical mixing of strata. No pollen leaching was present (cf. Ruppe' 1980:41-2).

Absence of Casuarina (Australian pine) in the samples lends additional support for pollen record integrity and its reliability for environmental reconstruction. The analyst had been requested to search specifically for this pollen, because its presence would indicate mixing of the strata below the marine sediments. Australian pine, an exotic species introduced after 1900, is the dominant vegetation on the barrier island inshore of the site. If the sediments had been significantly disturbed in this century, Casuarina would undoubtedly be present.

FAUNAL ANALYSIS

Although faunal material was usually ignored by salvors, some finds of bones and teeth were recorded in the early records from the Douglass Beach Site. In 1976 a 10-year compilation of field notes listed 30 entries for bones (Murphy 1976). These faunal remains, particularly Pleistocene species and a human cranium recovered in the 1960s, found at Douglass Beach raised the possibility of an inundated terrestrial site. In July 1966, salvors reported megafaunal remains (State of Florida site files). I observed these remains and recovered three bones in 1973 as a state field agent during commercial salvage operations. The dark-tan bones were contained in Anastasia formation. A review of state conservation laboratory records prior to 1974 produced 11 teeth (many appear to be Equus), 33 unidentified bones and 10 identified ones, the latter including four turtle and four cow bones, a fish maxilla and a deer horn. Unfortunately, site provenience is lacking, so the bones may have come from any of the shipwrecks being worked in the area.

In 1976 state field agents started recording occurrence and provenience for all faunal and aboriginal material, along with shipwreck-related artifacts. During the season 21 bones were recorded, including three Pleistocene horse teeth and four aboriginal bone pins. Little site excavation occurred in 1977.

The 1978 faunal material recovered is all that is available for study from the 1715 sites, because the state has given faunal material recovered in all other seasons to salvors (James Levy, personal communication). The state apparently attempted to maximize the number of shipwreck artifacts in its 25-percent portion, and consequently placed a low priority on faunal remains. The 1978 material was exempted from the salvors' artifact division by Cockrell, who was then the state underwater archeologist.

Field agents and salvage divers working on the Douglass Beach Project in 1978 collected more than 100 faunal specimens--more than twice the total amount for all 1715 sites recorded before then. All material removed from previously undisturbed areas was below the marine sediments and consequently older than 4800 B.P. Figure 5 is a site map depicting faunal distribution.

Table 1. 1978 Faunal Recoveries

MAMMALS: Homo Sapiens - 4 fragments of right calcaneus; 1 left talus, all appear to be from the same individual; 11 fragments of same bone - femur.
Equus sp. (Pleistocene horse) - 11 teeth
Odocoileus virginianus (deer) - distal end of humerus; 4 fragments from tibia shaft; 1 second phalanx, 3 fragments, 2 from same bone as is probable third, tibia.
Geomys cf.pinetis (pocket gopher) - right femur.
Unidentified mammals - 1 portion of mandible (not examined by zooarcheologist), 16 fragments probably from same bone; 2 fragments; 2 fragments from same bone; 1 fragment; 16 fragments from same bone; 1 fragment - head of scapula; 1 fragment scapula (?); 1 fragment - rib; 2 fragments.
FISH: Arius felis (catfish) - 1 bone; 2 fragments from the same bone; 1 bone.
Galeocerdo cuvieri (tiger shark) - 1 tooth.
Osteichthyes - 1 parasphenoid fragment; 1 unidentified fragment.
Dasyatis (stingray) - 2 fragments from the same bone; 1 bone.
cf. Bagre marinus (gafftopsail catfish) - Left supraoccipital fragment from large individual.
Epinephelus itajara (grouper) - 1 bone.
Pogonias cromis (black drum) - 1 vertebra.
Cynoscion nebulosus (sea trout) - 1 bone.
Lutjanus sp. (snapper) - 1 fragment.
Melongena corona - 1 complete shell.
Busycon - 1 shell tool, unifacially sharpened.
BIRDS - Aves - unidentified. 1 bone, ostial tibiotarsal.
REPTILES - Cheloniidae (sea turtle) - 14 fragments; 1 left pubis.
cf. Cheloniidae - 5 fragments.
Gopherus polyphemus (gopher tortoise) - 3 fragments; 1 fragment of xiphiplastron.
Kinosternon sp. (freshwater turtle) - 1 fragment.
Lepidochelys sp. (sea turtle) - 1 bone, possible humerus.
Chelonia mydas - (green sea turtle) 2 bones.
unidentified turtle - 5 fragments.
UNIDENTIFIED - 2 fragments from same bone; 57 fragments; 2 shaped bone pins (a total of 4 bone pins were recovered in 1978 and 4 in 1976).

The faunal material is well-preserved and at a level expected from burial with organics (Greg MacDonald, personal communication). The presence of multiple fragments of single bones indicates a minimal-transport depositional history. Bone appearance reflects a low-energy depositional environment with minimal transport: Except for some Pleistocene horse teeth, no faunal material shows evidence of sand wear; the edges and breaks are clean and sharp (e.g., Plates 1 and 2); fragile processes and delicate features are present, and the surface texture is clear. The horse teeth, all late Pleistocene, fall into two distinct groups, with no intermediaries: a brown-colored, well-rounded type, and a black-colored type that shows little wear. All are mineralized. Clearly two depositional and erosional histories are represented. Horizontal provenience reveals two groups that correspond directly to the worn-unworn categories. The worn specimens came from a 2-meter-deep offshore reef. The unworn teeth were found farther offshore beyond the reef in 3-4 meters of water. The shallower Anastasia reef was apparently eroded, exposing the Pleistocene materials and allowing movement sufficient to create sand wear. This wear probably took place during the last Pleistocene sea-level regression.

No conclusive evidence of cut marks, use or alteration was observed on any faunal specimens. The small size of some fragments can be attributed to human or scavenger activity.

Most specimens date at least to the Archaic Period, and are permineralized, indicating that none comes from the shipwreck. The faunal material contains a significant marine component, including grouper, shark and sea turtle.

The remainder of the species represents an estuarine and upland component. The total assemblage reflects a wide subsistence pattern prior to 4800-5000 B.P. (Milanich and Fairbanks 1980: 35-49). Although scant, the human material may represent a single burial. The presence of small bones and multiple fragments of a single bone indicates minimal movement. The relationship of the skeletal material recovered in 1978 and the cranium found in the 1960s is unknown.

ARTIFACT ANALYSIS

Only the prehistoric artifacts recovered in 1978 were analyzed to determine age and cultural affiliation. The shipwreck materials were transported to the state conservation laboratory, where they were documented and treated prior to the division with the salvor.

In 1978 11 prehistoric artifacts were recovered: five ceramic sherds, a shell tool, four bone pins and a small,

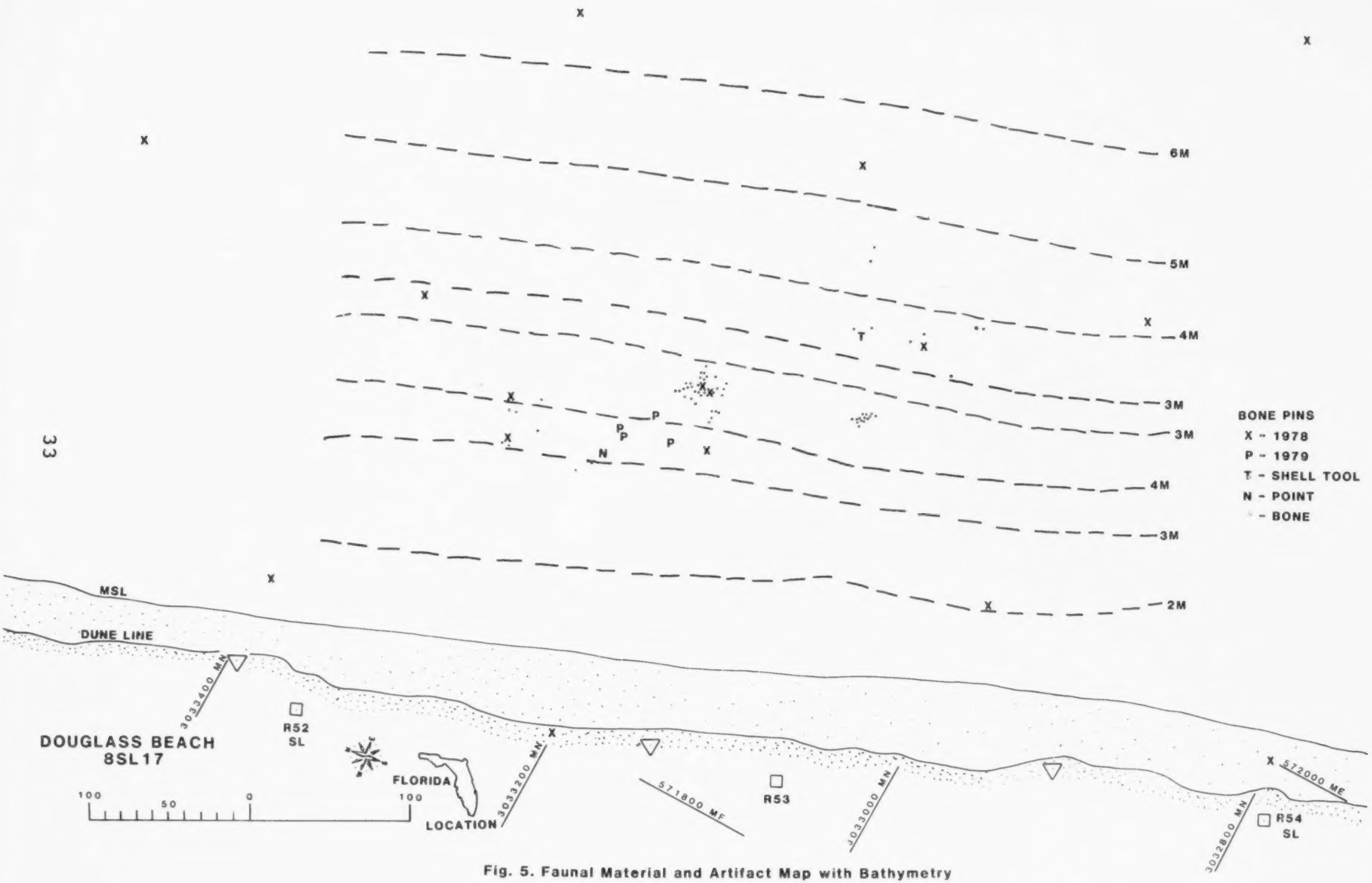

X
X
X
6M
X
5M
X
X
4M
T
X
X
X
3M
X
P
P
P
P
X
X
N
3M
4M
3M
X
X
2M
BONE PINS
X - 1978
P - 1979
T - SHELL TOOL
N - POINT
- BONE
MSL
DUNE LINE
3033400 MN
R52
SL
DOUGLASS BEACH
8SL17
X
FLORIDA
LOCATION
100
50
0
100
3033200 MN
571800 ME
R53
3033000 MN
X
572000 ME
3032800 MN
R54
SL

Fig. 5. Faunal Material and Artifact Map with Bathymetry

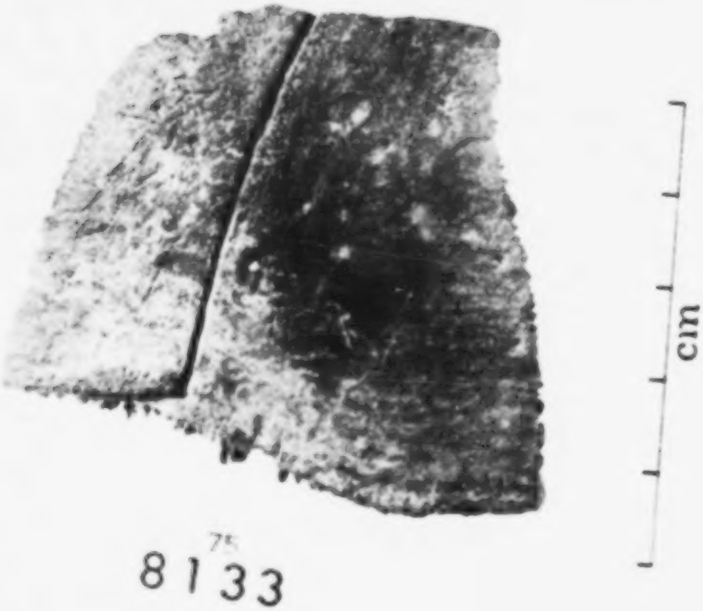


Plate 1. Gopherus polyphemus (gopher tortoise) xiphiplastron.

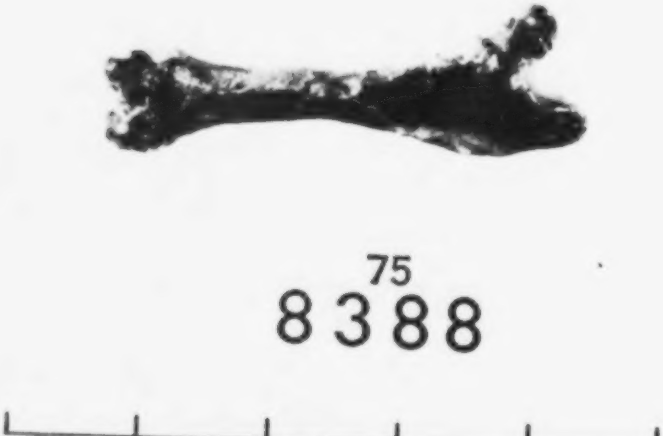


Plate 2. Geomys, cf. pinetis. (pocket gopher; right femur)

undiagnostic lithic flake. Only horizontal provenience exists for these artifacts.

The ceramics were recovered in previously dug areas and are well water-worn. Two of the dark sand-tempered sherds had a light-brown exterior.

The ceramics are Glades Plain, which Goggin and Sommer (1949:33-4) have described as a heavily sand-tempered paste with a partially smoothed and uneven exterior. Rouse (1951:247,250) found Glades Plain ceramics in the Douglass Beach region and considered them intrusive from the south. Glades pottery appeared circa 500 B.C. (Milanich and Fairbanks 1980:233). The shift from pre-Glades to Glades Period subsistence and settlement patterns, which occurred after sea level approached the present height, is described by Cockrell (1970).

The ceramics are much younger than the top stratum (Zone 3, 4500 B.P.) and therefore not associated with the older materials. The rounded, water-worn appearance of the sherds (Plate 3) indicates they have been subjected to the surf zone. Sherds possess a density similar to marine sand and are easily transported by waves and currents.

The Hoyt Midden site (8SL43), discovered in 1978 near DNR marker 52 at the Douglass Beach Site northern boundary, is the probable sherd source. Glades Plain and St. Johns Plain pottery were collected from the site. The Hoyt Midden is in a low-lying hammock area, which is subject to some erosion (Florida State Master Site File, Field Survey Form, Sept. 18, 1978).

A single shell tool (Plate 4) was recovered offshore from a previously dug area of Douglass Beach. The tool was microscopically examined for use wear. The shell surface appeared polished, and marine sand grains were observed wedged into small cracks in the body of the shell, indicating that the tool had been subjected to marine transport. However, the sides of the tool, which had been ground, and the working edge were relatively sharp and defined. The tool was not rounded like the rocks and shells located in the surf zone; overall indications are that it has not been subjected to the surf or offshore turbulence for a long period. The tool was probably uncovered by previous salvors, displaced and reburied. Its surface became polished and the sand grains embedded when the tool was moved during salvage operations.

Stylistically, the shell tool is consistent with the 4800 B.P. date of the Zone 3 stratum, while the ceramics are not. Many shell tools have been found in Middle Archaic contexts in Florida (e.g., Bullen and Bullen 1976; Clausen et al. 1979: 612; Masson 1988:313; Masson et al. 1988; Ritchie et al. 1981) and Texas (Mokry 1980).

Eight bone pins have been recovered from the Douglass Beach Site, four in 1976 and four in 1978 (Figure 6). A typical example is depicted in Plate 5. Most of the pins are permineralized but not water-worn, although some have discernible surface erosion. Numerous bone pins, typically manufactured from long bones of deer, have been recovered in Florida from Paleo-Indian, Archaic and later periods (Milanich and Fairbanks 1980:35-49, 102). They are particularly common in the Middle Archaic (7000-4000 B.P.) (e.g., Clausen et al. 1979:612; Beriault et al. 1981:48).

Two projectile points have recently been recovered from 8SL17 and examined by archeologists, although more have been reported (personal communication, Allen Saltus). A Middle Archaic Newnan's Lake Point (Plate 6), was recovered in 1979 (Figure 6). The point does not show the wear expected for lithics subjected to sediment-bearing waterflow (Shackley 1974). Newnan points have been recovered from 5400 B.P. burials at Tick Island (Bullen 1975:31), Little Salt Springs (Clausen et al. 1979:612) and the Bay West Site (Beriault et al. 1981:49), which are dated at 6000 B.P. The second point, recovered in the 1980s, was a 9500 B.P. Bolen Point (James Dunbar, personal communication).

In the 20-year period of excavations in the Douglass Beach no midden material and only one non-wreck feature has been reported. In 1984 salvors discovered a line of wooden stakes that were pounded into the ground. A 3 by 20-centimeter stake that was battered on one end and sharpened on the other was recovered and dated (4630 +- 100 B.P.). Wooden stakes and similar artifacts have been located in Archaic contexts (e.g., Beriault 1981:45-6). Wooden stakes associated with 7000 B.P. burials were recovered from the Windover Site in Florida (Doran and Dickel 1988:365, 368).

Little can be surmised about the nature of the terrestrial site at Douglass Beach beyond establishing its presence and age. Commercial exploitation of the shipwreck site has left few indications of site activity. Sedimentary and geochemical analysis of the site, however, can contribute to locating other continental shelf sites that can inform on coastal adaptations in Archaic and Paleo-Indian times.

SEDIMENTARY AND GEOCHEMICAL ANALYSIS

Sedimentary Analysis Methodology

Core sediments and three bulk samples recovered from the Douglass Beach Site were analyzed for sedimentary and

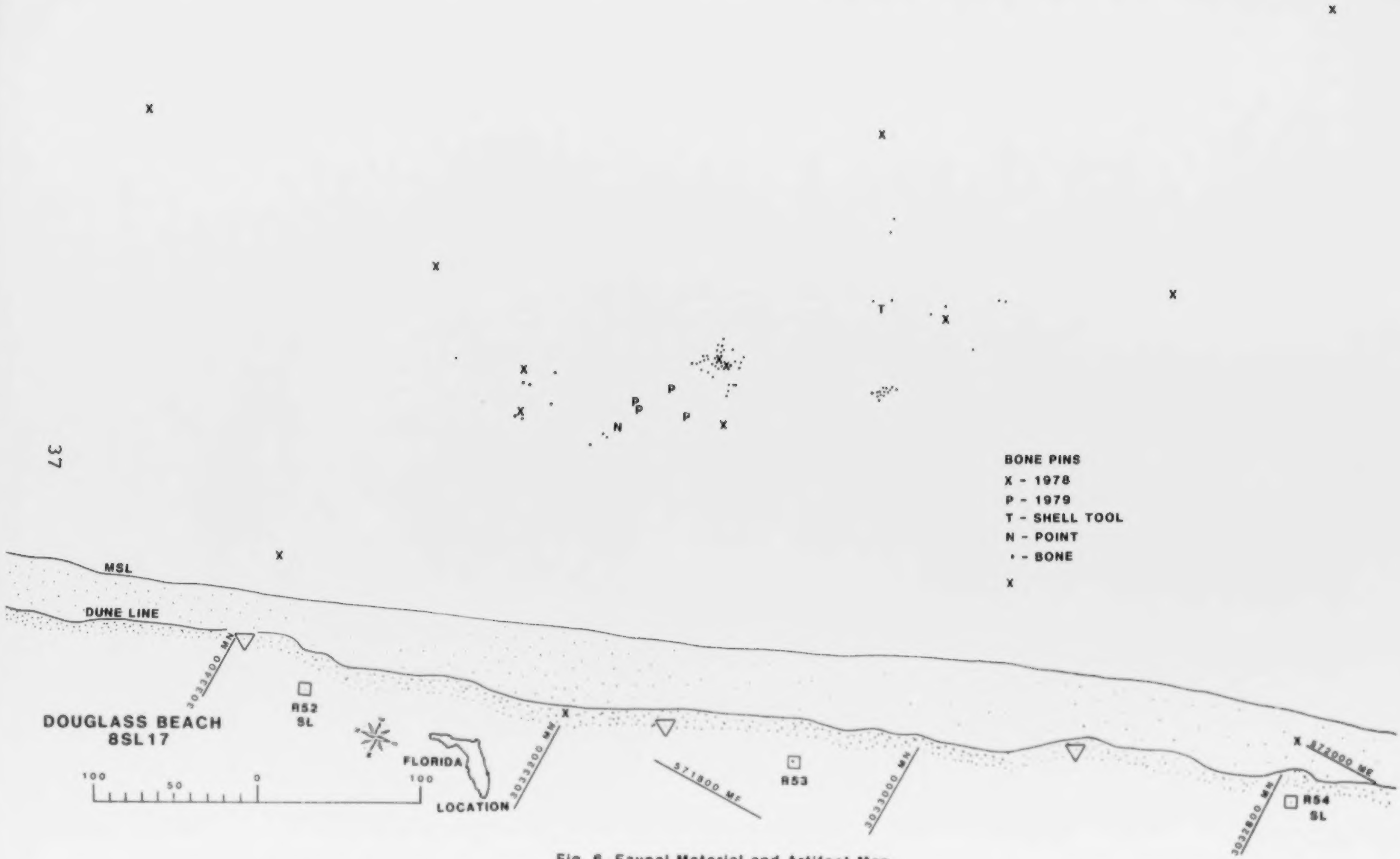

BONE PINS
X - 1978
P - 1979
T - SHELL TOOL
N - POINT
• - BONE
MSL
DUNE LINE
DOUGLASS BEACH
8SL17
3033400 MN
R52
SL
FLORIDA
LOCATION
100
50
0
100
3033200 MN
571800 MF
R53
3033000 MN
3032800 MN
R54
SL
572000 ME
X
P
T
N

Fig. 6. Faunal Material and Artifact Map

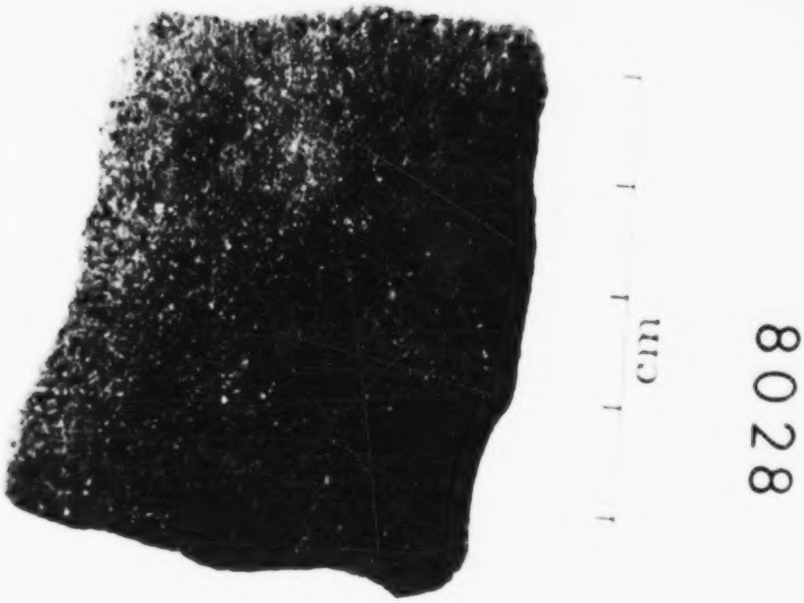


Plate 3. Sand - tempered ceramic sherd from Douglass Beach.

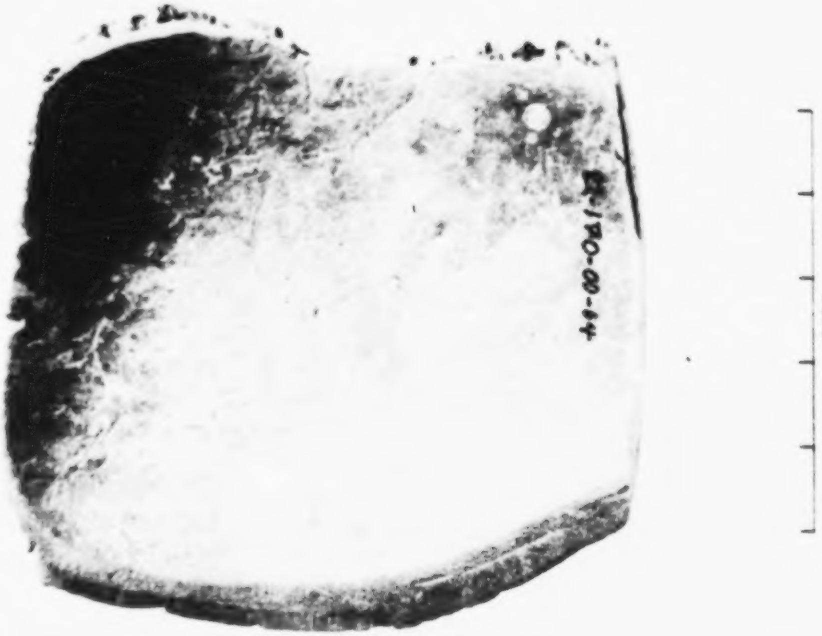


Plate 4. Busycon shell tool from Douglass Beach.

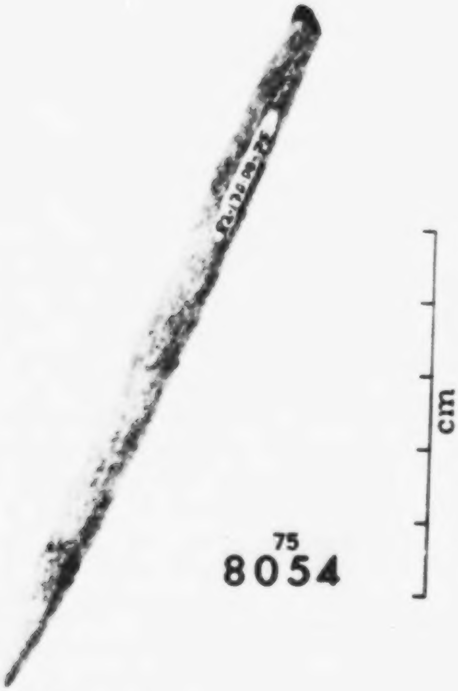


Plate 5. Bone pin from Douglass Beach.

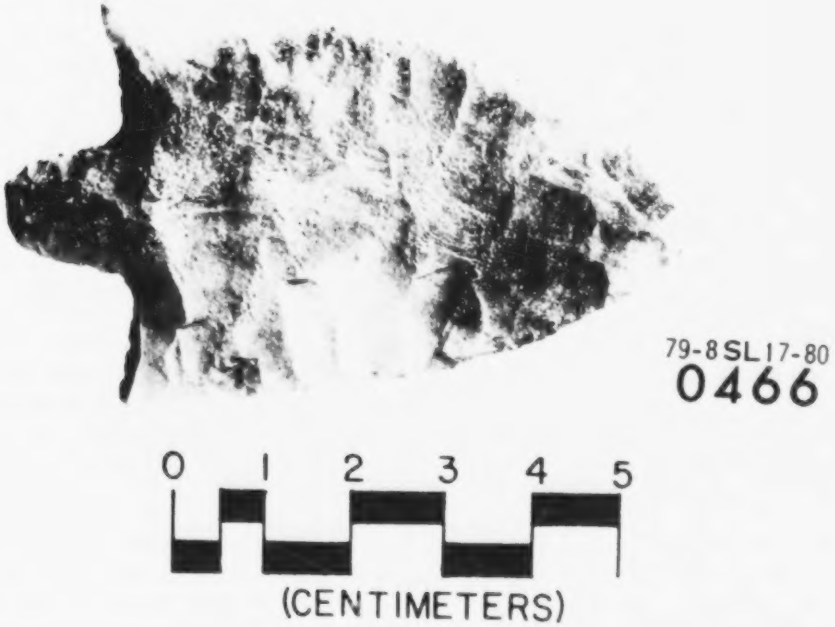

79-8 SL17-80
0466
0
1
2
3
4
5
(CENTIMETERS)

Plate 6. Newnan's Lake point recovered in 1979.

chemical composition and compared to the model developed for submerged sites of the Northern Gulf of Mexico by Gagliano (et al. 1982). Gagliano's model was developed as a methodology for submerged terrestrial site recognition in the Gulf of Mexico. The model has not been tested against known inundated sites, although it has been used in an attempt to locate inundated terrestrial sites in the Gulf (Pearson et al. 1986).

Douglass Beach provides the first opportunity to examine the sediments of a dated site to determine the deterioration, migration and leaching of chemicals in anthrosols submerged for millennia in seawater. Unfortunately, Douglass Beach Site data potential is limited due to the small number of samples collected and the lack of stratigraphic excavation. No comparative off-site samples were recovered in 1978, and the reliance on the prop-wash deflector precluded stratigraphic excavation. However, the core and bulk samples together allow stratigraphically discrete analysis and comparisons. Therefore, comparative analysis of the 8SL17 sediments can contribute to supporting and refining the Gagliano model, which is the most promising site-recognition tool available for continental shelf inundated terrestrial sites.

The Gagliano model provides a framework for assessing Douglass Beach Site disturbance. If the sedimentary and geochemical configuration of strata are distinct, minimal disturbance may be inferred; contrarily, similarity would indicate mixing. Quantitative and comparative analysis were expected to inform on depositional and transformational processes that have affected the site. Douglass Beach Site analysis followed procedures used by Gagliano, and a brief discussion of his methodology follows.

The Gagliano model was based on analyses of known terrestrial archeological sites associated with geological environments similar to relict features on the continental shelf. Fifteen terrestrial sites from Mississippi, Louisiana and southeast Texas were selected, representing eight coastal landforms, including barrier islands and estuarine margins. On- and off-site samples from terrestrial sites were subjected to standardized grain-size, point-count and geochemical analyses to develop criteria for distinguishing cultural from non-cultural deposits.

Grain-size analysis alone held little promise for establishing a definitive signature for cultural deposits, but was useful in delineating cultural deposit's nature and origin (Gagliano et al. 1982:94) and site-formation processes. Grain-size distribution was found to have little discriminatory value for site-sediment recognition except for levee sites.

For grain-size analysis, a geologist sorted the sample with shaker screens of standard mesh sizes to determine relative proportions by weight of each particle size. The Wentworth Grade Scale, which was developed to permit the direct application of statistical practices to sedimentary data (Bates and Jackson 1984:381), was used for analysis. A comparison of phi grades used and the corresponding fraction and millimeter size are given below:

Fraction	Phi Scale	Metric size
10	-1.00	2.000 mm
20	+0.25	.840
60	+2.00	.250
100	+2.75	.149
Pan	+4.00	.062

Point-count analysis involves microscopic examination and identification of particular fraction constituents. The results are presented as actual counts expressed as both the number of specific category elements and as the number of particles-per-kilogram of sediment.

Gagliano noted possible difficulties with the procedure: Not every particle can be counted; some particles will be incorrectly identified; and counting clumped materials can be problematic. Gagliano (et al. 1982:104) concluded there is little to be gained by analyzing the 100- and pan-size fractions because of large sampling error and the difficulty of identifying small particles. Point-count analysis should center on the 20 and larger fractions.

It would seem, however, that the relative amount of a particular fraction should be a consideration. If the 10- and 20-size fraction are but a small percentage of the overall sample weight, then significant sampling error is likely. Because these fractions contain the largest-sized fragments, and thus the fewer per unit of weight, using only the larger fractions might not accurately represent overall sample composition. Consequently, relative fraction proportions used for point-count analysis may be important.

Gagliano has developed site potentials based on qualitative (presence-absence) analysis of elements in larger fraction sizes, which may diminish the concern for sample size. Although the 10- and 20-fraction components averaged less than 10 percent of the total sediments, only these fractions were analyzed in the 8SL17 samples, following Gagliano's recommendations. The assumption that only the larger fractions need be point-count analyzed should be researched further, particularly in relation to relative fraction size.

Gagliano used a chi-square test for two independent variables with a Yates correction on the point-count categories of the on- and off-site samples to determine significant component categories for distinguishing between site and non-site sediments. Chi-square test results indicate that presence of Rangia shell, bone, and bone and charred material together in the 10 fraction and charred material or bone in the 20 fraction were significant indicators of cultural activity at the 0.05 significance level. Gagliano developed percentages of likelihood of the sediment being site-derived: A 100-percent likelihood of a sediment being culturally derived is proposed for the presence of bone, teeth and scales, as well as for bone and charred material together in the 10 fraction. In the 20 fraction, the likelihood of sediment being site-derived when charred material was present is 69 percent, and for bone and charred material together, 88 percent. The likelihood for a sediment being site-derived in the absence of these materials in either fraction is between 13 and 30 percent (Gagliano et al. 1982:104-5).

Discriminant analysis was used by Gagliano to determine the effectiveness of variables in distinguishing cultural from non-cultural sediments. The procedure is a quantitative technique for determining the statistical difference between two or more groups. Results are presented in a histogram that groups like and unlike groups. The technique attempts to distinguish the precise nature of differences between subgroups of a population, as measured by a number of variables. The general procedure of discriminant analysis is to search for those variables that discriminate between the groups most sharply (Johnson 1978:195-6). The two groups being discriminated were the on- and off-site samples based on significant point-count analysis variables.

> The comparison of all sites to all off-sites through discriminant analysis demonstrates that if no other information is known ... then the presence of bone and/or charred material in the 20 fraction and bone and/or Rangia shell in the 10 fraction are indicative that the sample is cultural . . . the simplest approach, qualitative (presence/absence) analysis of the contents of the large size fractions, is the most informative (Gagliano et al. 1982:107).

Results from Douglass Beach

Five of the six strata within the 1978 Douglass Beach core (Level 3 was sacrificed for a radiocarbon date) and three bulk samples of strata above the core were analyzed for grain size, point count and geochemistry. The results are presented in Appendices 1 and 2. Analyses followed Gagliano's methodology (Gagliano et al. 1982). The sample numbers in stratigraphic order from top to bottom are: 6 = Zone 3; 7 = Zone 2; 8 = Zone 1 (bulk samples); 3 (core level 1); 2 (core level 2); 1 (core level 4); 5 (core level 5); 4 (core level 6).

Grain Size Analysis

The high percentages of the 100 and pan fractions (Appendix 1), which represent the finest sediments, indicate either a terrestrial or quiet-water deposition. These fractions average 22 percent of the total, with a range of 12-39 percent. The 10 fraction, which contained the largest-sized sediments, average 8 percent, with a range of 1-18 percent. The 20 fraction averages 6 percent, with a range of 3-10 percent. The dominant fraction is the 60 fraction, which averages 52 percent of the total with a range of 36-72 percent.

Point-Count Analysis

The point-count analysis, also in Appendix 1, indicates the results of the 10-fraction and 20-fraction analysis. No Rangia shells were observed in any of the 8SL17 samples, and no other shells were identified beyond the categories of bivalve, gastropod and scaphopod.

Some categories different from Gagliano's were analyzed in the 8SL17 samples. For example, fish teeth and fish scales were separated from bone to determine the relative presence of bone, whereas in Gagliano's data summaries, these categories are combined. Sea-urchin spines are very fragile and numerous in the marine sediments, hence they are a good indicator of disturbance: If they are present, disturbance and mixing of the marine sea-floor sediments and the underlying strata can be inferred.

Tube-worm fragments, considered an indication of bioturbation, were recorded for Douglass Beach. Tube-worm fragments, which are from shell-lined burrows, indicate boring activity in the bottom sediments. Marine bryozoan colonies also indicate mixing if the sediments underlying the marine sea-floor sediments are demonstrated to be brackish or fresh water. Thus, sea-urchin spines, tube-worm fragments and bryozoan categories were used as indicators of site-formation processes, in this case, disturbance indicators.

Sea-urchin spines were found in all samples except 8, 5 and 4. Only one or two fragments were observed in each case. All strata except 8 contained tube-worm fragments, indicating sediment-burrowing organisms penetrated all sediments. The worm burrows account for sea-urchin spine presence in the absence of other evidence for sediment disturbance: The spine fragments apparently fall down the burrows, which can stay open after the animal dies. Wave activity can suspend the bottom sediments and allow spine fragments to enter the burrows. Presence of both sea-urchin spines and tube-worm fragments indicates some bioturbation and mixing of sediments. More research is needed to develop controls for marine bioturbation.

The 20 fraction of sample 6 contained the only bryozoan colony. This can be attributed to contamination or some mixing at the uppermost portion of the strata.

Qualitative appraisal of point-count analysis results isolates four possible habitation strata based on the presence of bone in the 20 fraction (which comprised less than 10 percent of the total sediments in all samples): samples 6, 7, 3 and 2. Sample 5 is added as a possible habitation stratum based on charred material in the 20 fraction. Considering both the presence of bone and charred material in the 20 fraction, samples 6, 3 and 2 are the most likely habitation. Strata 7 and 2 contain bone in the 10 fraction and meet Gagliano's second criterion. Sample 2 is the only stratum meeting both criteria. The 10 fraction of sample 2 is 23 percent of the total sediments. Sample 6, which had no bone in the 10 fraction, has a comparable fraction size at 18 percent; it is also the only sample that contains charred material in the 10 fraction.

Gagliano's criteria for qualitative analysis specifies bone, but his results include bone, teeth and scales together in a single category. The presence of fish scales and teeth combined with bone presents a different picture from the presence of bone alone, and indicates an inconsistency in Gagliano's model. All Douglass Beach strata possess fish teeth or scales in either fraction except sample 8. Therefore, on the presence of bone, fish teeth or scales, as stated in Gagliano (et al. 1982: 104), all sediments except sample 8 can be considered possible habitation loci based on point-count analysis. When considered together with the presence of charred material in the 20 fraction, only samples 6, 3, 2 and 5 are likely prospects.

Discriminant Analysis

Discriminant analysis was conducted on the point-count results and compared to Gagliano's results (Gagliano et al. 1982:100-01). Seven of Gagliano's on-site samples and five of his off-site samples were used for the comparison: Gagliano samples 41Gv66, 41Gv1, 22Ha500, 16Lf4, 22Ha506, 16Vm7,8 and 16Sb49 were used as the known on-site samples and samples 16Sb49, 16Vm7,8, 16Lf4 and 22Ha500 composed the off-site group.

The comparative analysis assigned on-site samples the number 1, off-site samples number 2 and the eight unknown samples from Douglass Beach, number 3. Each sample from the eight Douglass Beach strata was run separately with the entire Gagliano study population of known site relationships to determine if the Douglass Beach sample would statistically group with the on- or off-site group. Combinations of variables were run to determine discriminatory power and where each Douglass Beach sample grouped.

Few distinct discriminant variables are observed when both groups are statistically compared. However, some trends show consistency with the patterns reported by Gagliano.

Quantitative point-count discriminant analyses produce different results from the empirical presence/absence results for bone and charred material together in the 20 fraction, which indicates that strata 6, 3, 2 and 5 are possible sites. Using the bone, teeth and scales variable in the 10 fraction, strata 7, 2 and 5 are grouped with known sites; using the 20 fraction for the same variable, samples 6, 7, 3, 2, 5 and 4 are grouped with the known sites, 1 and 8 group with the off-site samples.

Using the variable of charred material in the 20 fraction, strata 6, 3, 2 and 5 group with the on-site samples, and 7, 8, 1 and 4 group with the off-site samples. This grouping does not change when qualitative bone (presence/absence), quantitative vegetal matter, charred material, bone, teeth and scales are analyzed together. Analysis of quantitative charred material in the 20 fraction also produces the same grouping. Qualitative analysis of bone, teeth, scales and charred material in the 20 fraction positions 6, 7, 3, 2, 5 and 4 with the on-site group, and positions 1 and 8 with the off-site group. For the 10 fraction, using qualitative bone, teeth and scales, only strata 8 and 4 group with the off-site samples. When charred matter is added to this analysis, the same results are produced. According to these variables, strata 8 and 1 are least likely to be culturally derived.

Discriminant analysis of the 8SL17 material and the Gagliano model indicates varying results when comparing the presence of bones, teeth, scales and charred material. Definitive signatures for continental shelf site types based on these variables await further refinement. Variable results are expected in this stage of model building, particularly with such a small universe of known on- and off-site data for comparison. The refinement of site recognition methodology will come with the development of regional signatures and comparisons with more known submerged sites.

Geochemical Analysis Methodology

A battery of geochemical tests designed to discern cultural activity was conducted on five of the 15 sites studied by Gagliano (et al. 1982). Results of this study were compared with similar tests of the Douglass Beach samples. Gagliano subjected the sediments of five selected sites, along with samples of nearby off-site sediment, to standard tests to determine the amounts of the following: total carbon and total nitrogen (expressed as a percentage), zinc, iron, manganese, copper and a variety of phosphate tests, including total phosphates, all expressed as parts per million (ppm).

The comparative results showed elevated phosphates in the on-site samples. Concentration of animal tissues on the site was likely responsible for the enriched manganese and zinc levels recorded. Discriminant analysis indicated that phosphates, zinc and iron-to-manganese ratio were the most discriminating variables (Gagliano et al. 1982:108-9). Gagliano advised caution in applying his results to other studies, because of the small sample size.

Three errors were noted in the results presented by Gagliano (et al. 1982). In Table 4-8, page 108, three iron-to-manganese ratios (Fe/Mn) were miscalculated. On-site sample 16VM7,8 recorded as 19.0 should be 3.1; 16Lf4 recorded as 24.0 should be 3.1; off-site sample 16Lf4 recorded as 74.8 should be 46.3. Statistical comparison with the Douglass Beach samples used the corrected ratios.

The geochemical analyses used for the Douglass Beach samples follow the protocol developed and recommended by Woods (1977; 1982; 1984; 1986; 1988a,b). The samples were ground and screened through a 2-millimeter sieve. Analysis included: electrometric measurement of pH of 1 part soil:2 parts water mixture; organic carbon determination by chromic acid digestion and titration; Kjeldahl digestion and titration for nitrogen; and plasma emission determination of calcium, magnesium, potassium, sodium, sulfur, zinc, manganese, copper, iron, boron, aluminum and total phosphates. Ratios of iron to manganese (Fe/Mn) and zinc to iron (Zn/Fe) were computed. Gagliano (et al. 1982) suggested the iron/manganese ratio and Templet (1986:296) suggested zinc/iron ratio as good indicators of human activity.

Other researchers have recognized phosphates, which may occur as tightly or moderately bound compounds, as a site discriminator. Site location, feature recognition and site delineation have all been done through phosphate determination (e.g., Woods 1975; Eidt 1984). Human residues, such as body waste, tissue decomposition, refuse concentrations and manufacturing introduce high phosphate concentrations. Phosphates are rapidly immobilized, insoluble, very stable and tend to remain in place unless mechanically disturbed (Eidt 1984:29-30; Woods 1986:195). Soils 10,000 years old have yielded increased phosphate levels attributable to human activity (Konrad et al. 1983). Water-logged and sandy soils may not be as stable as dry soils (Templet 1986:291; Woods 1988:3). Recent research (William I. Woods, personal communication) has found that contrary to earlier recommendations (e.g., Woods 1982; 1984; 1986) it is unnecessary to separate the various phosphate compounds out in analysis; total phosphate determination, a simpler laboratory analysis, can be used with confidence to indicate human activity. Only total phosphates were determined in analysis of Douglass Beach samples.

Other geochemical soil attributes have archeological significance. Anthrosols tend to have a higher pH because of increased alkalinity due to the presence of calcium, magnesium, sodium and potassium. Cultural activity increases these elements through many activities resulting in organic deposition and decomposition, but the prime source is wood ash (Woods 1988a:4). Increased iron in anthrosols likely comes from excreta. Concentrations of plant and animal tissues and excreta increase zinc and copper. Mollusca are particularly high in zinc (Woods 1988a:5). Organic matter increases with cultural activity, consequently, organic carbon can be used to determine buried surface horizons (Woods 1986:194).

Geochemical Analysis Results from Douglass Beach

Geochemical tests were conducted with satisfactory results in all categories except nitrogen. Nitrogen was below detectable limits in Kjeldahl analysis, a finding not unusual for sediments as old as Douglass Beach (William I. Woods, personal communication). Appendix 2 contains the results of the geochemical tests.

Discriminant Analysis

Discriminant analysis was run combining Gagliano's results and all Douglass Beach samples. Because all Douglass Beach samples grouped with the known off-site samples of the model, combinations of variables were run to isolate ones that might serve to discriminate anthrosols. The results of the comparison with the Gagliano model produced some promising directions for the refinement of inundated site recognition methodology, and these are included in the following discussion.

Total Phosphates: Samples 6, 8, 2 and 3 record the highest levels in the 8SL17 samples. Most of the Douglass Beach samples have lower levels than those of Gagliano's study, which could indicate a lower level of human activity. There was a very high reading from an off-site sample of the model (16Vm7,8 reading: 1216 ppm), which probably skews the statistical results--this known off-site sample is positioned with the on-site group.

Discriminant analysis does not produce discrete groupings between the on- and off-site samples when all samples are combined. Although the histogram looks promising, there is considerable overlap between on- and off-site samples when a single unknown sample is analyzed. Douglass Beach samples 1, 2 and 6 are grouped with the on-site samples.

Zinc: On- and off-site samples overlap, but zinc should be discriminatory. All 8SL17 samples are grouped with the off-site group.

Iron to Manganese Ratio: On- and off-site samples overlap, but the variable may be a useful discriminator. Strata 6, 7, 3 and 2 are grouped with the on-site group. 8, 1, 5 and 4 are in the off-site group.

Zinc to Iron Ratio: Templet (1986:296) found through multiple regression analysis and correlation tables that both the zinc/iron and total phosphates indicate anthrosols at a 95-percent level of confidence. A discriminant analysis was run with both variables of phosphate and zinc/iron ratio together. There was an overlap of on- and off-site groupings (probably due to the high phosphate reading of one of the off-site samples), and the 8SL17 samples fell between the known groupings.

Anthrosol determination by geochemical analysis is promising. However, the current coastal model does not appear capable of definitively isolating specific strata of human activity. At the current level of development, geochemical analysis may be most useful for delineating the spatial extension of a site and defining intra-site features. At present, there are insufficient data to propose a generalized geochemical signature for conclusively indicating anthrosols.

Combinations of variables rather than a single attribute seem better able to isolate anthrosols. Discriminant analysis was conducted on Douglass Beach samples using variables of presence/absence of bone, teeth and scales, charred material, and quantitative phosphate separately for the 10 and 20 fraction. The results of both analyses indicate this combination may be a good discriminating tool, as Gagliano's model implies, because the on- and off-site samples are distinctly grouped. The results of comparison with the unknown samples in both cases positions samples 2, 3, 5 and 6 with on-site, and 1, 4, 7 and 8 with the off-site samples.

These findings suggest that combinations of variables that include geochemical with 10 and 20 point-count analysis may be the best analytic method for assessing unknown sediments for site possibilities, whereas individual variables may be more useful in defining intra-site features. The combination of point-count analysis combined with phosphate and zinc/iron ratios may be especially useful.

The results of analysis indicate clearly that the Douglass Beach strata are geologically and geochemically distinct, and consequently, could not have been significantly disturbed by wave processes. If wave action had reached these sediments in the past, the sediments would have been geochemically indistinguishable, even if differentially sorted. Sediment leaching may be discounted because of the range of variability throughout the stratigraphic column.

The radiocarbon dates, non-ceramic artifacts, pollen and faunal materials are consistent with the interpretation of an Archaic Period site directly beneath the seabed. The preservation level of remains indicates minimal site disturbance and material transport. The intrusive ceramics are, in contrast, water-worn, revealing significant transport.

Qualitative analysis of point-count data indicate that all strata are site-related except for sample 8, and possibly 1. The geochemical discriminant analysis groups different Douglass Beach strata with Gagliano's on-site group depending which variables are selected: phosphate and zinc both group all strata with the off-site group; iron/manganese ratio groups 6, 7, 3 and 2 with on-site group; zinc/iron ratio groups Douglass Beach samples between the on- and off-site groups; and the combination of qualitative bone, teeth, scales, charred material and phosphate groups strata 2, 3, 5 and 6 with the on-site group.

Douglass Beach Site analysis results have some implications for the Gagliano model. Some bioturbation and wave disturbance can be controlled for by the inclusion of additional analytical categories, such as sea-urchin spines and worm-tube fragments, additional indicators need to be identified. Qualitative point-count categories need to be clarified as to the inclusion of teeth and scales with bone. Finally, particular combinations of variables may be more appropriate than single ones for site discrimination, while single variables may be better for intra-site feature delineation.

CHAPTER V: CONCLUSIONS

The 1978 Douglass Beach Site excavation provided an opportunity to examine an underwater site with a prehistoric occupation beneath a 1715 Spanish shipwreck. The object of the investigation was to ascertain the nature of the prehistoric component--the earliest continental shelf site located--and account for its preservation. Research questions centered on natural formation processes of both components.

Fieldwork was conducted in the context of commercial shipwreck salvage, which imposed serious constraints on archeological inferences. Development of sound archeological inferences depends on collecting evidence to account for variability in the archeological record. Archeological variability has many sources, including those introduced by methodology. Archeologists normally determine what is recorded, recovered and curated, but that is not the procedure in Florida on shipwreck sites. The 1715 shipwreck excavation has been a commercial operation, and archeologists have mostly been involved in salvage program administration, not field work. Consequently, few materials from seasons other than 1978 can be used as supporting evidence for archeological inference.

Methodological limitations to the 1978 research stemmed from the commercial aspects of the fieldwork. Location of excavation and recovery of material could only be influenced, not directed. Sole reliance on the prop-wash deflector severely limited data collection and observation, and obviated stratigraphic excavation. Using a prop wash for anything other than removing sterile sediment is precisely the same as using a bulldozer for archeological excavation of a land site--instead of approaching ancient materials with the finesse of trowels and brushes, it is an instrument of massive destruction.

Deflector modifications allowed some stratigraphic observation and sample collection. Three principal stratigraphic zones were recorded, and samples for radiocarbon, palynological, sedimentary and geochemical analysis were collected. Macrobotanical samples, bulk soil samples and a core were recovered with stratigraphic association.

Analyses indicate that the prehistoric component beneath the shipwreck is well-preserved. The stratum directly beneath the marine sand dates at 4800 B.P. Artifacts are consistent with an Early to Middle Archaic occupation, except for ceramics, which show signs of sand wear, likely transported from a site onshore. Faunal material, containing both marine and terrestrial species, was well-preserved. Pollen was undamaged and consistent with established regional paleoenvironments that contained marsh- and salt-tolerant species. Viability of geochemical analysis was demonstrated for salt-water inundated sites. Sedimentary and geochemical analysis together indicate the prehistoric strata are discrete, well-preserved and have suffered no mechanical disturbance. The analyses demonstrated archeological data sets that survive inundation and submersion. The site-location model developed by Gagliano et al. (1982) was tested and some refinements were suggested, including development of a multiple-element geochemical signature for archeological sites and inclusion of marine fauna residues as a control for bioturbation.

Barrier-island formation and migration account for the unexpectedly high level of preservation of the Douglass Beach terrestrial site in a high-energy area. Human occupation took place when the site was an upland or back-barrier lagoonal environment. As the sea level rose, the barrier island moved shoreward. Sand overwashed onto the back-barrier zones and buried associated sites. The lagoon also moved shoreward, inundating areas that contained upland sites. Consequently, lagoon-related sites may lie over earlier upland sites.

A barrier island moves much like a giant tank tread, laying down a layer of sand by overwash as it migrates shoreward. The island moves completely across and buries the old lagoonal and upland deposits below the wave base and surf zone on the barrier island foreshore. Variables in the rate of sea-level rise and barrier migration, and in the depth of both lagoonal deposit burial and the wave base, interact in the transgressive sequence to affect preservation of archeological materials.

The wave base will likely truncate the stratigraphic profile, but wave disturbance is limited and diminishes with the rise of sea level. The active wave-base level should be recognizable in the stratigraphy. The wave base's signature is a stratum below the seabed of materials of high specific gravity, size and weight. One possible wave erosional effect on archeological materials is that younger artifacts may concentrate at the wave base as upper levels erode. Consequently, a disturbed level of younger artifacts may overlay undisturbed, older sediments. Careful stratigraphic excavation is necessary to recognize this phenomenon.

At Douglass Beach, shipwreck materials aided recognition of the processes affecting preserved sediments. The presence of silver coins, numerous rocks and other heavy materials in marine sand directly above a 4,800-year-old undisturbed stratum clearly indicated significant wave action. The top layer (Zone 3) of the older stratum was composed of fine, unconsolidated friable sediments, which would rapidly disperse if subjected to wave action. The proximity of coins and other heavy materials indicates that the wave base has been deep enough to intersect back-barrier sediments since 1715. This observation provides a signature for wave-action depth and a means to control for disturbance.

Schiffer (1987), Butzer (1982) and others have discussed the importance of formulating general principles of site-formation processes to account for variables in the archeological record. The natural processes responsible for the position and preservation of artifacts and stratigraphy of the Douglass Beach site are uniformitarian. As a result of investigations at Douglass Beach, I suggest two new general principles for addition to the growing body of natural-formation processes influencing archeological enquiry. These principles are important to the development of archeological inferences from underwater sites and are offered for further testing.

1. Artifacts whose specific gravity is greater than the surrounding sand, which are deposited in sand deeper than the wave base, will migrate downward to the wave base and stabilize.

2. Barrier-island migration preserves back-barrier, lagoon-related and upland sediments and related archeological sites from the mechanical impact of inundation.

There are many implications for the investigation of shipwrecks and inundated sites. For shipwrecks, it is clear that spatial provenience is important even in storm-deposited, high-energy environments. In the sandy areas of the Douglass Beach shipwreck, heavy artifacts do not move about horizontally but are stabilized. This observation obviously counters the disaster-and-degeneration view of wrecks in high-energy environments. Derivation of supportable archeological inferences about the past based on shipwreck evidence requires specific scientific research on natural-formation processes. The archeological potential of wrecks will be limited as long as this scientific research is delayed.

However, scientific research alone is not enough. Most current state historical shipwreck salvage laws reflect disaster-and-degeneration assumptions. Shipwrecks are diminishing at an ever-increasing rate, and growing commercial exploitation poses a severe threat. The Douglass Beach observations augment the evidence that shallow-water shipwrecks retain a high degree of site integrity. Commercial salvage is an increasingly indefensible governmental policy and must be reevaluated, or discussions of archeological potential of historic shipwrecks will be academic.

For inundated terrestrial sites located in high-energy environments, the implications are especially significant for site location and evaluation. Archeologists earlier assumed that inundated sites would be preserved only on low-energy coastlines like parts of the Gulf of Mexico. Consequently, in the search for submerged sites they have ignored the Southeast Atlantic shelf and surveyed only in the Gulf, obviously assuming that high-energy coastal processes destroy land sites during inundation.

The Douglass Beach site demonstrates that barrier-island migration can preserve sites. Furthermore, the model for offshore site location can be expanded to include submerged, remnant barrier features. Most current site-location models focus on relic riverine features in low-energy areas. Such models are based on narrow assumptions and are inadequate.

Because of their linearity, elevation and characteristic sedimentary profile, barrier islands can be recognized during remote-sensing surveys. Ancient barriers have been located on the southeast continental shelf and off the coast of Delaware. The Delaware barriers developed between 8000 and 14000 B.P. The most promising targets for Atlantic shelf sites are areas beneath and seaward of remnant barrier islands. Such areas can be located with high-resolution remote-sensing survey.

It is unlikely that the inundated site at Douglass Beach would have been located with any current site-location model. There is little question that a site like 8SL17 would be difficult to locate, but without a predictive model based on geomorphological factors and a methodology for distinguishing cultural from non-cultural sediments, the task would be impossible. Constant reappraisal, testing and refinement of predictive models for sites on the continental shelf and development of recognition methodologies are the precursors to realizing the archeological potential of offshore sites.

To achieve this potential, it is time to put aside the old disaster-and-degeneration assumptions and take a scientific, investigative approach to understand site formation processes.

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APPENDIX 1 RESULTS OF SEDIMENTARY AND POINT COUNT ANALYSIS

Sample #6

Fraction, Phi	Weight, grams	% of total
-1.00	81.69	18.26
+0.25	39.33	8.79
+2.00	172.93	38.64
+2.75	43.65	9.75
+4.00	70.46	15.75
silt & clay (by diff.)	39.43	8.81
Total	447.49	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	42	365	75	6562
Gastropod shell	10	87	17	1487
Scaphopod shell				
Shell fragment	376	3264	276	24146
Carbonate concretion			2	175
Cemented silt or sand	29	252	15	1312
Coarse sand			20	1750
Fish teeth	1	9		
Fish scales				
Bone			3	262
Worm tube or fragment	9	78	3	262
Crustacean fragment	1	9	1?	87
Sea urchin spine	1	9		
Bryozoan colony			1	87
Vegetal matter			1	87
Charred vegetal matter	1	9	1	87
Total counted	470		415	
Wt. of amount counted, grams	21.03		1.0046	

Sample #7

Fraction, Phi	Weight, grams	% of total
-1.00	7.39	7.97
+0.25	5.11	5.51
+2.00	53.65	57.83
+2.75	8.87	9.56
+4.00	12.73	13.72
silt & clay (by diff.)	5.02	5.41
Total	92.77	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	15	162	21	907
Gastropod shell	14	151	16	691
Scaphopod shell				
Shell fragment	168	1810	158	6821
Carbonate concretion				
Cemented silt or sand	67	722	59	2547
Coarse sand			208	8979
Fish teeth	8	86	4	173
Fish scales			4	173
Bone	1	11	2	86
Worm tube or fragment	2	22	7	302
Crustacean fragment	1	11	2	86
Sea urchin spine			2	86
Bryozoan colony				
Vegetal matter			2	86
Charred vegetal matter				
Total counted	276		485	
Wt. of amount counted, grams	7.39		1.2760	

Sample #8

Fraction, Phi	Weight, grams	% of total
-1.00	1.87	1.56
+0.25	3.91	3.26
+2.00	86.44	72.02
+2.75	11.49	9.57
+4.00	3.58	2.98
silt & clay (by diff.)	12.73	10.61
Total	120.02	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell				3042
Gastropod shell				
Scaphopod shell				
Shell fragment	9	75	11	209
Carbonate concretion	2	17		
Cemented silt or sand			549	10409
Coarse sand			514	9746
Fish teeth				
Fish scales				
Bone				
Worm tube or fragment				
Crustacean fragment				
Sea urchin spine				
Bryozoan colony				
Vegetal matter				
Charred vegetal matter				
Total counted	11		1074	
Wt. of amount counted, grams	1.87		1.7182	

Sample #3

Fraction, Phi	Weight, grams	% of total
-1.00	16.68	7.32
+0.25	19.51	8.56
+2.00	83.50	36.64
+2.75	16.66	7.31
+4.00	67.95	29.65
silt & clay (by diff.)	23.59	10.52
Total	227.89	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	78	693	85	7506
Gastropod shell	57	578	37	3267
Scaphopod shell				
Shell fragment	238	2114	215	18986
Carbonate concretion				
Cemented silt or sand	43	382	31	2737
Coarse sand			8	706
Fish teeth	1	9	1	88
Fish scales				
Bone			1	88
Worm tube or fragment	6	53	3	265
Crustacean fragment			1?	88
Sea urchin spine			2	177
Bryozoan colony				
Vegetal matter				
Charred vegetal matter			1	88
Total counted	423		385	
Wt. of amount counted, grams	8.24		0.9695	

Sample #2

Fraction, Phi	Weight, grams	% of total
-1.00	43.11	23.08
+0.25	20.27	10.85
+2.00	76.61	41.01
+2.75	9.52	5.10
+4.00	29.41	15.74
silt & clay (by diff.)	7.87	4.22
Total	186.79	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	57	646	109	11875
Gastropod shell	51	578	13	1416
Scaphopod shell				
Shell fragment	318	3605	195	21244
Carbonate concretion				
Cemented silt or sand	34	385	15	1634
Coarse sand			10	1089
Fish teeth	4	45	1	109
Fish scales	1	11		
Bone	1	11	2	218
Worm tube or fragment	4	45	4	436
Crustacean fragment			2	218
Sea urchin spine			1	109
Bryozoan colony				
Vegetal matter	1	11		
Charred vegetal matter			1	109
Total counted	471		353	
Wt. of amount counted, grams	20.36		0.9961	

Sample #1

Fraction, Phi	Weight, grams	% of total
-1.00	3.43	3.39
+0.25	5.15	5.09
+2.00	67.16	66.32
+2.75	12.13	11.98
+4.00	10.35	10.22
silt & clay (by diff.)	3.05	3.00
Total	101.27	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	11	109	164	3042
Gastropod shell	4	39	35	649
Scaphopod shell				
Shell fragment	89	879	322	5972
Carbonate concretion			9	167
Cemented silt or sand	21	207	279	5175
Coarse sand			400	7420
Fish teeth				
Fish scales	1	10		
Bone				
Worm tube or fragment	2	20	14	260
Crustacean fragment	1?	10		
Sea urchin spine			2	37
Bryozoan colony				
Vegetal matter			3	56
Charred vegetal matter				
Total counted	129		1228	
Wt. of amount counted, grams	3.43		2.7416	

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Sample #5

Fraction, Phi	Weight, grams	% of total
-1.00	4.35	3.19
+0.25	6.49	4.76
+2.00	84.16	61.69
+2.75	15.27	11.19
+4.00	11.92	8.74
silt & clay (by diff.)	14.23	10.43
Total	136.42	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	21	154	28	874
Gastropod shell	19	25	8	250
Scaphopod shell			1	31
Shell fragment	98	718	82	2558
Carbonate concretion	2	15	4	125
Cemented silt or sand	48	352	250	7800
Coarse sand			411	12824
Fish teeth	5	37	2	62
Fish scales	1	7	2	62
Bone				
Worm tube or fragment	5	37	6	187
Crustacean fragment	1	7	1	31
Sea urchin spine				
Bryozoan colony				
Vegetal matter				
Charred vegetal matter			1	31
Total counted	200		796	
Wt. of amount counted, grams	4.35		1.5247	

Sample #4

Fraction, Phi	Weight, grams	% of total
-1.00	4.47	3.79
+0.25	10.26	8.69
+2.00	53.17	45.04
+2.75	7.51	6.36
+4.00	8.92	7.56
silt & clay (by diff.)	33.71	28.56
Total	118.06	100.00

Component	-1.00 Phi		+0.25 Phi	
	Actual count	Particles per kg	Actual count	Particles per kg
Bivalve shell	8	68	6	409
Gastropod shell	3	25	2	136
Scaphopod shell				
Shell fragment	148	1253	157	10713
Carbonate concretion	3	25		
Cemented silt or sand	96	813	417	23457
Coarse sand			18	1228
Fish teeth			1	68
Fish scales				
Bone				
Worm tube or fragment	1	8		
Crustacean fragment				
Sea urchin spine				
Bryozoan colony				
Vegetal matter			1	68
Charred vegetal matter				
Total counted	259		602	
Wt. of amount counted, grams	4.47		1.2735	

APPENDIX 2: RESULTS OF GEOCHEMICAL ANALYSIS OF THE 8SL17 SAMPLES

Results are in parts per million, except where otherwise indicated. Samples are listed in stratigraphic order top to bottom.

Sample	Ph	Organic Carbon	Zinc	Iron	Manganese
6	7.0	0.41%	8.128	3212	42.365
7	7.6	0.36%	3.518	1473	16.181
8	8.0	0.19%	6.589	5317	23.551
3	6.9	0.50%	12.754	3600	40.290
2	8.3	0.11%	8.683	1468	18.585
1	7.4	0.27%	12.488	1759	13.731
5	7.2	0.40%	10.788	10487	30.345
4	8.0	0.41%	15.234	16227	63.738

Sample	Calcium	Phosphorus	Magnesium	Potassium	Sodium
6	178544.8	434.83	2133.15	974.28	3867.98
7	94295.5	191.66	1150.95	671.50	3143.21
8	15239.3	84.11	1120.60	1099.67	2953.45
3	89910.2	455.99	1745.50	1071.84	4196.23
2	163420.5	400.68	1074.34	660.98	2248.20
1	57474.9	259.20	641.84	764.43	1732.09
5	51780.8	147.64	1576.90	1885.37	4778.03
4	168502.8	501.03	2697.38	2266.64	6616.36

Sample	Sulfur	Zinc	Copper	Boron	Aluminum	Fe/Mn	Zn/Fe($\times 10^3$)
6	3100.0	8.13	4.14	19.46	3042.7	75.8	2.53
7	1408.3	3.52	18.74	9.65	1189.6	91.4	2.39
8	3459.7	6.59	6.31	10.47	4711.3	226.0	1.24
3	2565.8	12.75	7.10	11.16	7801.5	893.0	3.54
2	1239.0	8.68	5.51	8.29	1347.7	78.9	5.91
1	1548.2	12.49	8.21	6.72	735.7	128.4	7.10
5	7208.3	10.79	5.12	11.63	7117.8	346.1	1.02
4	13468.8	15.23	6.45	19.46	11946.0	254.0	9.39

APPENDIX 3

POLLEN ANALYSIS OF A SEDIMENT CORE AT 8SL17, THE DOUGLASS BEACH SITE

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INTRODUCTION

A sediment core and three bulk samples collected from beneath the Gold Wreck (8SL17) at the Douglass Beach Site in 1978 represent prehistoric sediments beneath later Spanish material. The core was collected approximately 1 meter below the existing beach sand in approximately 12 to 15 feet of water. Three bulk samples were collected for analysis above the core. A dark, organic layer was included in the core, which may represent a backwater lagoon. The present backwater lagoon is located behind a barrier island. The top layer of the sediment was radiocarbon dated to approximately 5000 B.P. (Murphy, personal communication, August 1988). Pollen analysis of these sediments was designed to address questions of local vegetation, identification of backwater lagoonal conditions, if present, and to contribute data for analysis and interpretation of site formation processes. In addition, the vegetation is discussed with respect to possible availability of edible portions that may have been exploited by inhabitants of this site.

METHODS

The pollen was extracted from soil samples submitted by Larry Murphy from deposits off Ft. Pierce Beach in Florida. A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for the removal of the pollen from the large volume of sand, silt and clay with which they are mixed. This particular process was developed for extraction of pollen from soils where preservation has been less than ideal and pollen density is low.

Hydrochloric acid (10%) was used to remove calcium carbonates present in the soil, after which the samples were screened through 150 micron mesh. Sodium polytungstate (density 2.0) was used for the flotation process. All samples received a short (10 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples were then acetolated for 3 minutes to remove any extraneous organic matter.

A light microscope was used to count the pollen to a total of 100 to 200 pollen grains at a magnification of 430x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University, the University of Colorado Herbarium, and from the field station on the island of San Salvador in the Bahamas was used to identify the pollen to the family, genus and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen, and may be interpreted to represent pollen dispersal over short distances, or the actual introduction of portions of the plant represented into an archaeological setting. Aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram.

Indeterminate pollen includes pollen grains that are folded, mutilated, and otherwise distorted beyond recognition. These grains are included in the total pollen count, as they are part of the pollen record.

DISCUSSION

The sediment core analyzed for pollen at Douglass Beach, near Ft. Pierce, Florida in approximately 12-15 feet of water (Table 1). The uppermost bulk sample yielded a radiocarbon age of approximately 5000 B.P. (Larry Murphy, personal communication, December 1988), making all sediments analyzed older than 5000 years. The present on-shore vegetation is dominated by Australian pine (Casuarina), a recent introduction. No Casuarina pollen was observed in the pollen record, suggesting that the sediments analyzed have not suffered mixing in the recent (historic) past.

Analysis of the sediments suggests that an organic layer (represented by pollen samples 2 and 3) may be an emergent marsh. Deposits above and below this layer contain significantly less organic matter and are described as washover sands and shell hash. The only exception is the uppermost level (pollen sample 5), which may contain lagoonal mud with windblown or washover sand and shell (Larry Murphy, personal communication, August 1988). The pollen record in sample 5 is vastly different from that in samples 2 and 3, however.

Three bulk samples were collected from the sediment layers from Zones 1, 2 and 3 above the sediment core. This sediment was loose and readily blown by the excavating equipment. A radiocarbon age of approximately 5000 B.P. is reported for Zone 3, the uppermost zone sampled and analyzed for pollen.

The sediment core may be described as having six levels. Level 1 is the uppermost, and is represented by pollen sample 5. This level is gray in color and contains numerous shells. Level 2 is represented by pollen sample 4. This level is yellow-brown, with some gray deposits, particularly towards the base. Shells were numerous in this deposit. Level 3 is a dark organic layer, and is represented by pollen samples 2 and 3. A carbonate date of 9110 +- 310 B.P. was obtained for this layer. The sample was not large enough to allow pretreatment of the carbonates, so the date is suspect. Level 4 is a gray lens underlying the dark, organic concentration. This lens also contains shells. Level 5 is a coarse sand, yellow in color and exhibiting evidence of oxidation. Level 6 is another coarse sand, gray in color. This was the basal deposit sampled for pollen.

The pollen record contains three major components: Pinus, Cheno-am and Gramineae pollen (Figure 1, Table 2). The Pinus pollen probably represents transport from pines in wooded areas farther inland. It is possible that the increases in Pinus pollen occur with the decrease in local non-arboreal vegetation, thereby apparently increasing the relative quantity of pine pollen in the record. Pine pollen is very readily transported on the wind, and may contribute to the pollen record in locations where it does not grow in the immediate vicinity. Increases in Cheno-am and Gramineae pollen are interpreted to indicate increases in local vegetation, including possibly pigweed, members of the goosefoot family, and members of the grass family.

TABLE 1
PROVENIENCE OF POLLEN SAMPLES ANALYZED

Sample No.	Depth in inches below top of core	Sediment Type	Pollen Counted
Bulk 9	Zone 3		200
Bulk 10	Zone 2		200
Bulk 11	Zone 1		100
5	2-3	Coarse sand, gray	200
4	10-11	Coarse sand, yellow-brown, containing shells	200
3	12.5-13.5	Dark, organic, black, few shells	200
2	14.5-15.5	Dark, organic, black, few shells	200
1	17-18	Coarse sand, gray	200
6	23-24	Coarse sand, gray with shells	Insuff
7	19.5-20.5	Coarse sand, yellow-brown, oxidized	100

TABLE 2
POLLEN TYPES OBSERVED IN SAMPLES FROM 8SL17

Scientific Name	Common Name
ARBOREAL POLLEN:	
Carya	Hickory, Pecan
Castanea	Chestnut
Corylaceae	Birch or corylus family
Myrtaceae	Eucalyptus family
Pinus	Pine
Quercus	Oak
Salix	Willow
NON-ARBOREAL POLLEN:	
Anacardiaceae	Sumac family
Boraginaceae	Borage family
Caryophyllaceae	Pink family
Cheno-ams	Includes amaranth and pigweed family
Compositae:	Sunflower family
Artemisia	Wormwood
Low-spine	Includes ragweed, cocklebur, etc.
High-spine	Includes aster, sunflower, etc.
Cyperaceae	Sedge family
Gramineae	Grass family
Liliaceae	Lily family
Nyctaginaceae	Four o' clock family
Ranunculaceae	Buttercup family
Sesuvium	Sea-purselane
Tribulus	Puncture vine
Typha	Cattail

Other elements of the pollen record include *Carya*, cf. *Castanea*, Corylaceae, Myrtaceae, *Quercus* and *Salix* as representatives of the tree communities. The presence of this variety of tree pollen suggests that the area inland from Douglass Beach may have been wooded with a variety of pines and hardwoods for the period represented, which is 5000 B.P. and before. It is unusual that there is no Cupressaceae or Taxodiaceae pollen from these deposits, as these families are expected to contribute heavily to the local tree populations. The pollen from these families are virtually indistinguishable, and are usually combined in pollen reports. A deposit of peat (Cockrell and Murphy 1978a), several well-preserved tree trunks, human bone, and artifacts made from stone, shell and bone have been recovered from this

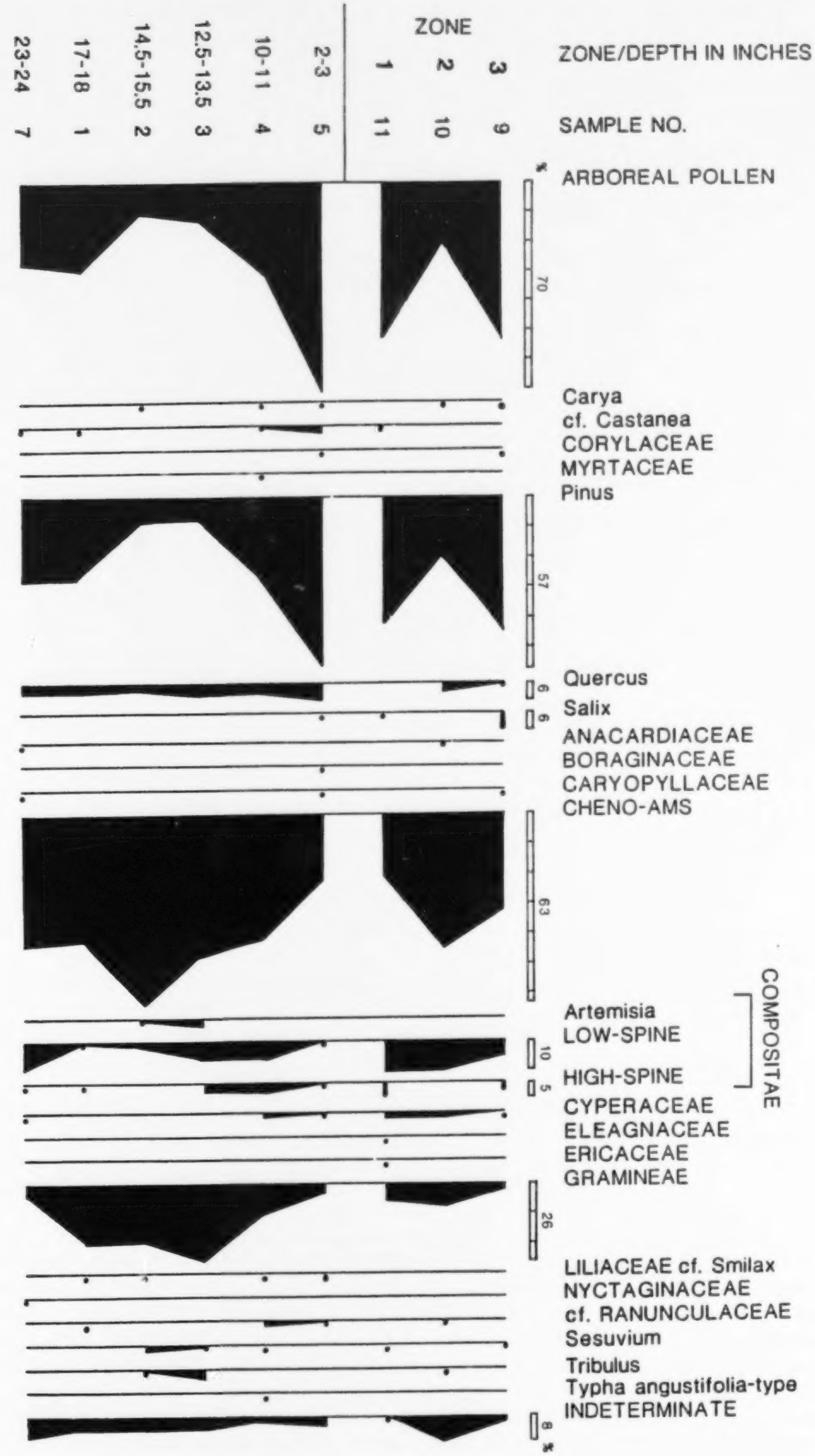

FIGURE 1. POLLEN DIAGRAM FROM THE DOUGLAS BEACH SITE, FLORIDA.

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site. The presence of hardwoods surrounding the area is reported from this evidence by Cockrell (1980).

Evidence for a drier, cooler environment supporting a remnant deciduous forest, which extended into the Florida peninsula, is reported by King (1975 in Cockrell and Murphy 1978b) and Watts (1969, 1971 in Cockrell and Murphy 1978b). General reconstructed vegetation for the period approximately 5000 B.P. describes most of Florida as covered by the Southeastern Evergreen Forest and relies primarily on interpretations of the arboreal portion of the pollen record. These conditions hold true even at 10,000 B.P. (Delcourt and Delcourt 1985). The Southeast Evergreen Forest is the dominant vegetation type, and does not preclude the presence of a variety of hardwoods in isolated stands or small quantities. It should be noted that the reconstruction of the vegetation at 200 B.P. is also Southeastern Evergreen Forest. The large quantities of Pinus pollen in the pollen record from the Douglass Beach Site throughout most of the core sampled is consistent with published reconstructions of an evergreen forest. Subtle changes in effective precipitation and fire frequency may affect local constituents of this major vegetation community (Delcourt and Delcourt 1985).

The non-arboreal portion of the pollen record may address questions of local vegetation and the possible presence of lagoonal or marsh conditions. Pollen samples 2 and 3 were collected from the dark, organic level which was interpreted from a preliminary sediment analysis to probably represent marsh or lagoonal sediments. These sediments displayed an increase in both Cheno- am and Gramineae pollen, suggesting that pollen produced by these locally abundant plants overshadowed the pine pollen being transported from the nearby evergreen forests. Many members of the Cheno-am pollen group are opportunistic or invade disturbed areas and act as primary colonizers. Many are also tolerant of saline in the soils and air and may have contributed to the local marsh vegetation. The designation Cheno-am refers to the family of Chenopodiaceae (goosefoot family), as well as the genus Amaranthus (pigweed). This type of pollen is produced abundantly by these plants, and is also readily wind transported. Wherever they grow they contribute to the pollen record. If the plants are abundant, they frequently dominate the pollen record.

The large frequencies of Gramineae pollen, also, may reflect a local marsh. Gramineae pollen is particularly high in samples 1, 2 and 3 collected immediately below the dark, organic layer, and inside the dark, organic layer. Other samples contain significantly less Gramineae pollen. Some grasses tolerate saline and brackish conditions and may be associated with coastal marshes. Such a grass is Spartina (cord- or marsh-grass). This grass is a common component of brackish and freshwater coastal marshes (Fernald 1950).

Pollen from the Compositae (sunflower family) is noted primarily in samples collected above and below the organic layer. Several genera from this family grow well in disturbed habitats. This family includes genera that inhabit a broad range of habitats. Therefore, no interpretations are made concerning the distribution of this pollen.

Cyperaceae (sedge) pollen is noted in relatively small quantities throughout much of the later portion of the pollen record. Sedges may occupy habitats similar to grasses, and/or be found in wet areas.

Sesuvium (sea-purslane) pollen is noted in several samples, and represents an annual tolerant of the saline conditions of damp, coastal sands, where it grows. _Tribulus_ is an annual that prefers dry, open sandy ground. It is not expected to grow in the marshy areas, but may have grown inland from the coastal sands and marshy areas. Some members of the lily family are also adapted to brackish water conditions, such as _Smilax_. A single _Smilax_-type pollen was observed in pollen sample 5. Other Liliaceae pollen observed are the typical monosulcate forms. _Typha_ (cattail) pollen was observed only in sample 4. This suggests that marsh conditions persisted somewhere in the vicinity.

Pollen sample 6, collected from the base of the core, did not yield sufficient pollen for analysis. This sample contained an abundant quantity of what appeared to be small pieces of charcoal. The few pollen grains observed were in a poor state of preservation.

The pollen record from the core displays patterns that correlate with the observed strata. Pollen samples 2 and 3 correspond with a very dark, organic lens that appears to represent marsh sediments. These two samples display the smallest quantities of _Pinus_ pollen observed in this study. This may be due to an increase in vegetation in the area being sampled. Locally, the vegetation appears to experience a dramatic increase in grasses, which were probably a major component of the marsh. The composites all but disappear from the pollen record at this time, to reappear later when there is no evidence of a marsh. _Sesuvium_ pollen is highest in Sample 2, which may indicate a coastal strand community at the edge of the marsh, since _Sesuvium_ is tolerant of salt spray, and frequently grows near the coast. The increase in Cheno-am pollen probably also reflects an increase in these plants in the local vegetation under marshy conditions. These plants may have grown at the edge of the marsh, benefitting from the marshy habitat without growing directly in it. Cheno-am pollen is readily wind transported, so increases in this pollen type may be associated with increased vegetation in the general vicinity of the marsh, rather than within the marsh itself.

The upper portion of the core is marked by a prominent increase in Pinus pollen, and decreases in Cheno-am, Gramineae and other non-arboreal pollen. This suggests the possibility that most of the pollen recovered in the upper portion of the core was wind transported from other vegetation communities, rather than representing vegetation at the location cored. This may happen if the area cored had been underwater during deposition of these sediments. The upper portion of the core is very similar to the lowest bulk sample.

Three bulk samples were collected from Zones 3, 2 and 1 above the cored sediments. These upper sediments were fragile, and readily obliterated by the blower during excavation, and so were sampled by hand. The pollen record from these levels are represented in Samples 9, 10 and 11. These samples, as well as the uppermost core samples, display relatively large quantities of Pinus pollen, which represents wind transport from the nearby forested areas. The Cheno-am frequencies are moderately high, with the peak occurring in Zone 2. Low- and High-spine Compositae pollen probably present local components of the vegetation. The Gramineae pollen frequencies are relatively low, particularly when compared with the high frequencies recovered immediately prior to and within the marsh sediments. The small quantity of Cyperaceae pollen recovered in all of the bulk samples is similar to that recorded in the upper portion of the core. Cyperaceae pollen was not recovered in samples collected from the marsh deposits. Sesuvium, which grows well in sandy deposits, and is tolerant of salt spray, and thus successfully grows near shorelines, is observed in Zones 1 and 3.

Pollen that represents trees or plants that may have contributed to the subsistence base of inhabitants of this area include: Carya, Quercus, Cheno-ams, Gramineae, Liliaceae and Typha. Both Carya (hickory) and Quercus (oak) produce edible nuts. Nuts are a more concentrated food source than seeds or greens, and are frequently collected preferentially to other resources. Although apparently not abundant in the local environment, it is probable that both acorns and hickory nuts would have been exploited if they were available.

Acorns are noted to have been an important food historically (Reidhead 1981, Yarnell 1964). Both bitter and sweet acorns have been gathered and used for food. Sweet acorns, produced by white oak, are relatively small and require a longer time to collect than do bitter acorns. In addition, a good crop of acorns is produced by white oaks only approximately every four to ten years. The bitter acorns, commonly produced by red and black oaks, are larger than sweet acorns and tend to have high yields every two to three years. Average figures for acorn production varied between .6 and 8.6 pounds of unshelled nuts per tree. White oak acorns sprout readily shortly after falling to the ground, frequently within three or four weeks. Red and black oak acorns, however, may lie on the ground for months before sprouting, which elongates the time available for collection. In addition, the sweet acorns are more desirable to animals and pests, and thus there is increased competition for these nuts. The bitter taste, produced by tannins within the acorns, may be readily removed from the acorn meat by pulverizing the acorns, placing them in fine nets, then submerging them in streams or rivers. This is a relatively effective treatment for removing tannins and is not labor-intensive (Reidhead 1981). Acorns were most commonly ground into flour, which may have been used to thicken soup stock or cooked into bread, used as a pudding base, as a mush, or with other foods. The nuts may also be roasted and eaten whole (Reidhead 1981).

Hickory (Carya) nuts are recorded as the most important nut used by Indians of North America at the time of contact (Reidhead 1981). Hickory nuts were commonly reduced to butters or oils for consumption. Competition with animals is likely, as squirrels begin harvesting hickory nuts before they fall from the tree. Hickory nuts were usually shelled by crushing the entire nut, then separating the nutmeats and shell through a water separation or water flotation. Frequently the water was boiled or the nuts placed in a soup. Oils extracted from the nuts during this process were consumed with the water or soup. Nutmeats could be strained from the top of the water, while nutshells fell to the bottom and were easily discarded. Occasionally the nutmeats were separated with cold water, which was agitated causing the meat and oils to rise and shells to sink. Stone mortars and pestles are also noted to have been used to crush the nuts. Larger wooden mortars are noted to have been used historically for processing larger quantities of hickory nuts. Hickories produce a good yield approximately once out of every one to five years. Reidhead (1981) reports an estimated average yield of approximately 15 pounds per tree.

Cheno-ams are a group of plants that include the goosefoot family (Chenopodiaceae) and pigweed (Amaranthus) and were exploited for both their greens (cooked as potherbs) and seeds. The greens are most tender when young, in the spring, but may be used at any time. The seeds were ground and used to make a variety of mushes and cakes. The seeds are usually noted to have been parched prior to grinding. Chenopodium and Amaranthus are both weedy annuals capable of

SUMMARY AND CONCLUSIONS

The pollen record from the Douglass Beach Site (8SL17) suggests that the major vegetation inland consisted of an evergreen forest composed primarily of pines. In addition, pollen from hardwoods was also noted, indicating that hardwoods were a part of the tree community. The local vegetation, which is probably represented by the non-arboreal pollen, displays an increase in grasses in samples 1, 2 and 3. Sample 1 immediately predates the dark, organic layer, and probably indicates the beginning of the formation of marshy conditions. The pollen record indicates that a marsh develops and is responsible for the production of the organic material in the core represented by pollen samples 2 and 3. Production of pollen by the local marsh vegetation displaces a portion of the pine pollen, which is present through longer distance wind transport, during this period. The marsh and environs immediately surrounding the marsh appear to have supported grasses, as well as other plants including Cheno-ams and possibly members of the lily family. Sesuvium and Tribulus, both noted in the pollen record from the marsh deposits, probably grew in damp or drier coastal sands. The pollen record suggests that prior to the formation of the marsh deposits, local vegetation was typical of sandy beaches, and farther inland supported primarily the Southeastern Evergreen Forest. Pollen samples associated with the marsh deposits (samples 2 and 3) display higher frequencies of plants and families containing members that are salt tolerant (particularly the grasses and Cheno-ams). The marsh declines or ceases to exist immediately above the dark, organic level. The presence of Typha (cattail) pollen in sample 4 suggests that at least a portion of the marsh remains in the vicinity of the area sampled. By the uppermost level (pollen sample 5), however, all evidence of the marsh vanishes from the pollen record. Pollen samples collected as bulk samples from the sediments above the core suggest a period of local disturbance in Zone 2 that interrupted the dominance of the pollen record by Pinus pollen, representing long distance transport from the Southeastern Evergreen Forest. The pollen samples from Zones 1, 2 and 3 suggest that conditions were fairly constant at this time, with the possible exception of Zone 2, which records a slight increase in Gramineae and an increase in Cheno-am pollen, suggesting an increase in local vegetation, which affects the representation of Pinus pollen through long distance transport.

The pollen record displays evidence of a number of trees and plants that may have been exploited as food items by native prehistoric inhabitants. The trees include hickory and oak. Both produce edible nuts, which would probably have been gathered even if the trees were not abundant locally.

Other plants that may have been utilized for food include Cheno am seeds or greens, grass seeds, lily roots, and cattail roots or pollen. The pollen record indicates that the local vegetation may have provided a variety of vegetal items for exploitation by a prehistoric population.

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